SILICON CHIP

APRIL 2019
ISSN 1030-2662
04
9 771030 266001
PP255003/01272
$9.95* INC GST NZ $12.90 INC GST

The VERY BEST DIY Projects!

FEATURE:

FACIAL RECOGNITION

Is BIG BROTHER really watching you?

ARDUINO SEISMOGRAPH UPDATE:

Adding a Geophone for greater sensitivity

Introducing the icestick

Now YOU can easily program FPGAs!

Don't know what an FPGA is? We explain that too!

FREE with this issue

Jaycar Electronics

2019 Catalog

We review the latest Altium Designer 19

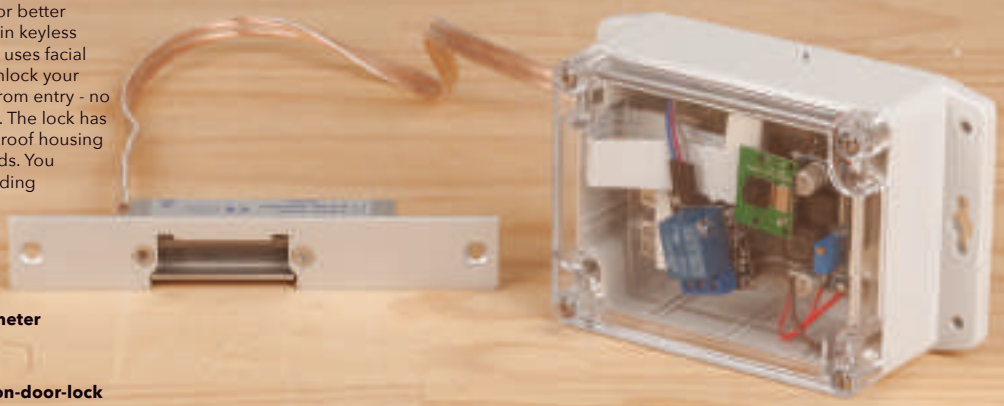
awesome projects by **jaycar**

On sale 24 March to 23 April, 2019

Our very own specialists are developing fun and challenging Arduino® - compatible projects for you to build every month, with special prices exclusive to Nerd Perks Club Members.

PROJECT OF THE MONTH:
Face Recognition Door Lock

See who is trying to enter your room or better still why not use this technology to gain keyless access to your workshed! This project uses facial recognition technology to lock and unlock your door and even block certain people from entry - no longer technology just for the movies. The lock has an RPI camera in a transparent waterproof housing and can recognise faces within seconds. You can register hundreds of faces depending on you storage capacity.
(SD card and 12V power supply not included)



SKILL LEVEL: Beginner
TOOLS: Soldering iron, Drill, Multimeter

See step-by-step instructions at:
www.jaycar.com.au/face-recognition-door-lock

WHAT YOU NEED:

Raspberry Pi 3B+ Board	XC9001	**$84.95**
Electric Door Strikes	LA5077	**$44.95**
5MP Camera for Raspberry Pi	XC9020	**$24.95**
IP65 Enclosure with Mounting Flange 115(W) x 90(D) x 55(H)mm	HB6251	**$17.95**
DC Voltage Regulator	XC4514	**$7.95**
150mm Socket to Socket Jumper Leads	WC6026	**$5.95**
5V Relay Board	XC4419	**$5.45**
4 Way Push Connection Speaker Terminal	PT3002	**$2.95**

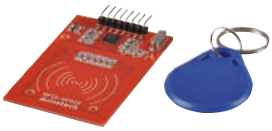
NERD PERKS BUNDLE DEAL
$149

SAVE OVER $40

KIT VALUED AT: $195.10

See other projects at www.jaycar.com.au/arduino

Key it



ONLY **$19.95**

RFID read and write kit
Add an extra layer of security by using RFID cards. XC4506

Animate it

ONLY **$19.95**

Mini servo 4.8V-6V
Allow the unit to move signs, open boxes, and more automation types of movements. YM2760

Prompt it

ONLY **$22.95**

Mini communications speaker
Add voice prompts by software, telling the user what to do. AS3185

Interact it

ONLY **$159**

1024 x 600 HDMI 7" touch screen
Have a touch panel interface for that extra sci-fi kick. XC9026

Exciting launch April 1st
nerd perks in DIGITAL# rewards faster + new perks!
See website for details + new T&Cs April 1st

#Card free club with eCoupon rewards: we've phased out cards but member cards & Jaycoins cards can still be used until expired. Is your email up to date? Check in store or online now.

new catalogue out now!
FREE catalogue*

for Nerd Perks Members with purchases of $30 or more.
***Applies to new & existing members for purchases made in-store or online.**
Valid 1 April - 23 April.

JUST $4.95

Shop the catalogue www.jaycar.com.au 1800 022 888

Contents

Vol.32, No.4; April 2019

SILICON CHIP

www.siliconchip.com.au

Features & Reviews

14 Big Brother ~~may be~~ IS watching you: Facial Recognition!
If you've ever had the feeling that you're being watched, you are! From social media apps to law enforcement, from banks to airports, facial recognition is used to identify YOU and plot wherever you go – by Dr David Maddison

32 Introducing the iCEstick: an easy way to program FPGAs
This compact PCB which plugs into your computer's USB port takes the mystery out of programming field programmable gate arrays (FPGAs). In fact, we regard the iCEstick and its software as "beginner friendly" – by Tim Blythman

70 Review: Altium Designer 19
The latest version of this world-wide (Aussie!) PCB design software (and the one we use here at Silicon Chip) is more evolutionary than revolutionary but it has some great new features to make designers' lives much easier – by Tim Blythman

Constructional Projects

22 Flip-dot Message Display
You've seen them on buses, in airports, etc – those mechanical message boards with huge, clear letters. Now you can make your own with this project – there's virtually no limit to the length of the message you can make – by Tim Blythman

38 Ultra low noise remote controlled stereo preamp – Part 2
We continue the description – and importantly, construction – of our new ultra low noise and distortion stereo preamplifier. It works with just about any power amp and offers infrared remote control and bass/treble adjustments – by John Clarke

58 iCEstick VGA Terminal
Want a project to have that "early PC" look? We take the iCEstick FPGA USB stick and IceStudio software to make a modern monitor look like it's displaying old-style VGA text – by Tim Blythman

80 Arduino Seismograph revisited – improving sensitivity
A reader has suggested adding a "geophone" to further improve the sensitivity of our Arduino-based Seismograph (April 2018). We tried it – and it works! Construction is so simple it can fit on a stripboard – by Tim Blythman

Your Favourite Columns

53 Serviceman's Log
A laptop, spilled tea and a crack – by Dave Thompson

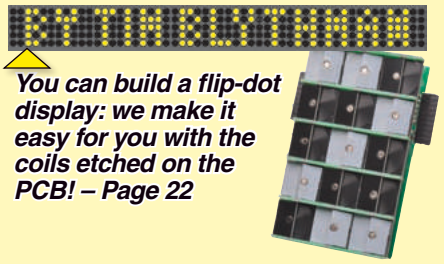
76 Circuit Notebook
(1) Simple zener diode tester fits inside a DMM
(2) Automatic sleep timer for TVs

84 Vintage Radio
Healing 404B Aussie compact – by Ian Batty

Everything Else!

2 Editorial Viewpoint
4 Mailbag – Your Feedback
88 Silicon Chip Online Shop
90 Product Showcase
91 Ask Silicon Chip
95 Market Centre
96 Advertising Index
96 Notes and Errata

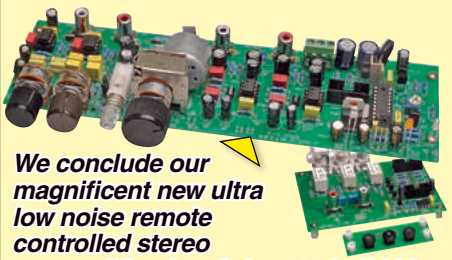
Like it or not, you're now being watched and identified most of the time. Facial recognition is now said to be able to ID anyone – even in a crowd! – Page 14



You can build a flip-dot display: we make it easy for you with the coils etched on the PCB! – Page 22

iCEstick: the easy way to program FPGAs, even for beginners. – Page 32

And we use the iCEstick to produce VGA graphics in this "retro" project – Page 58



We conclude our magnificent new ultra low noise remote controlled stereo preamplifier; here's how to build it! – Page 38

Altium Designer 19

A new year brings a new Altium Designer – the world's most widely used PCB software. Here's what version 19 offers – Page 70

Find us on Facebook

www.facebook.com/siliconchipmagazine

SILICON CHIP
www.siliconchip.com.au

Editor Emeritus
Leo Simpson, B.Bus., FAICD

Publisher/Editor
Nicholas Vinen

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Jim Rowe, B.A., B.Sc
Bao Smith, B.Sc
Tim Blythman, B.E., B.Sc

Technical Contributor
Duraid Madina, B.Sc, M.Sc, PhD

Art Director & Production Manager
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Dave Thompson
David Maddison B.App.Sc. (Hons 1), PhD, Grad.Dip.Entr.Innov.
Geoff Graham
Associate Professor Graham Parslow
Ian Batty

Cartoonist
Brendan Akhurst

SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 626 922 870. ABN 20 880 526 923. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Subscription rates: $105.00 per year, post paid, in Australia.
For overseas rates, see our website or email silicon@siliconchip.com.au

Editorial office:
Unit 1 (up ramp), 234 Harbord Rd, Brookvale, NSW 2100.
Postal address: PO Box 139, Collaroy Beach, NSW 2097.
Phone (02) 9939 3295.
E-mail: silicon@siliconchip.com.au

ISSN 1030-2662
* Recommended & maximum price only.

Printing and Distribution:
bluestar
Derby Street, Silverwater, NSW 2148.

Editorial Viewpoint

Nannies want to stop you building mains-powered projects

Just before this issue went to press, I received a product safety complaint via NSW Fair Trading, alleging that SILICON CHIP magazine is unsafe. Apparently, this is because we explain how to build mains-powered devices, such as the Touch & IR Remote Control Dimmer featured in February and March this year.

We take many steps to ensure that our readers, and anyone who builds these projects, is fully aware of the hazards and also the steps to be taken in order to safely build, test and operate those devices.

If you read last month's construction article for the Touch & IR Dimmer, you will see that right up front we point out that you need a licensed electrician to wire up the dimmer. Be it on your own head if you ignore that advice!

And we provide numerous safety warnings when circuits are directly powered from mains or involve high voltages, including a general warning published in every issue of the magazine, on the second-to-last page.

Critically, we also provide detailed instructions explaining how to safely build and test these devices. If you follow those instructions carefully, you will be fine. We design our projects to comply with the relevant Australian Design Rules, so assuming you follow our instructions and don't skip any steps, the finished product will be safe.

These steps include Earthing metal chassis, properly insulating and anchoring all mains conductors and adding extra insulation where necessary.

Our Technical Editor has a great deal of knowledge and experience with Australian electrical standards and he will scream in my ear if he thinks anything we're planning to publish is sub-par or illegal.

He points out that the history of publishing mains-powered designs for the general public to build goes back nearly 100 years to the early days of Wireless Weekly. Radio, TV & Hobbies and Electronics Australia continued that tradition; and for nearly 32 years now, so has SILICON CHIP.

We are not aware of anyone being injured due to an electrical shock from any SILICON CHIP design, although we are aware of a Coroner's Court finding related to a project in another magazine which resulted in a death because a reader took short-cuts in a mains powered project.

While I am a very risk-averse person, I have no qualms designing, building and testing mains-powered devices, simply because I use common sense. I keep all parts of my body well away from all conductors when powering up mains devices, and I make sure they are unplugged and capacitors have discharged before working on them again. I have never received an accidental shock.

But if the nannies get their way, we may not be able to present mains-based designs in the magazine any more, meaning you will not have a chance to read about them or build them. I don't know about you but that makes me angry.

Mains power is dangerous. It can easily kill you if you manage to connect your body between Active and Neutral or Active and Earth. But it isn't that hard to stay safe. Read our articles carefully, follow our advice, use common sense and you will be fine.

We do things which can kill us every day: cross the road, drive to work, eat a sandwich, lift weights, climb a ladder etc. We accept these minimal risks and we do what we can to reduce them. Why should building mains-powered electronics projects be any different?

Do you think SILICON CHIP magazine is really "unsafe"? Hint: don't try to swallow it. You might choke.

Nicholas Vinen

In Stock & On Time
The World's Largest Selection of Electronic Components Available for Immediate Shipment™
FREE SHIPPING ON QUALIFIED ORDERS*
AUSTRALIA
DIGIKEY.COM.AU
1800 285 719
NEW ZEALAND
DIGIKEY.CO.NZ
800 449 837
Digi-Key ELECTRONICS
7.6 MILLION+ PRODUCTS ONLINE | 750+ INDUSTRY-LEADING SUPPLIERS | 100% AUTHORIZED DISTRIBUTOR
*Australia: A shipping charge of $24.00 AUD will be billed on all orders of less than $60.00 AUD. A shipping charge of $20.00 USD will be billed on all orders of less than $50.00 USD. All orders are shipped via UPS, Federal Express, or DHL for delivery within 3-4 days (dependent on final destination). No handling fees. All prices are in Australian dollar or United States dollar. New Zealand: A shipping charge of $26.00 (NZD) will be billed on all orders of less than $66.00 (NZD). A shipping charge of $20.00 USD will be billed on all orders of less than $50.00 USD. All orders are shipped via UPS for delivery within 3-4 days (dependent on final destination). All prices are in New Zealand dollar or United States dollar. Digi-Key is an authorized distributor for all supplier partners. New product added daily. Digi-Key and Digi-Key Electronics are registered trademarks of Digi-Key Electronics in the U.S. and other countries. © 2019 Digi-Key Electronics, 701 Brooks Ave. South, Thief River Falls, MN 56701, USA
ECIA MEMBER
Supporting The Authorized Channel

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask Silicon Chip", "Circuit Notebook" and "Serviceman".

GPS units may be affected by week rollover

I have just become aware that the GPS week number is a 10-bit value and that it rolls over on April 6, 2019.

More information and a countdown are at: https://www.gps.gov/

Winston Campbell,
Coonabarabran, NSW.

Comment: most newer receivers should handle this OK. It will be interesting to see whether anything fails when this occurs.

Losing the ability to make emergency phone calls

Thanks for publishing my letter on making emergency phone calls post-NBN in your March issue (pages 10 & 12). Following the major power failure in Hornsby on February 13th & 14th, I now have some first-hand answers regarding the reliability of the mobile phone network during a power outage.

The power failed around 12:15pm on the 13th. Two and a half hours later, all the 3G carriers were off the air. I asked my mobile phone to do a scan of available carriers and it could only find a very weak signal; too weak to use. I cannot say if the 4G network was also down at this time as my phone does not support 4G.

I noticed one base station with a mobile generator attached at around 6:45pm, so it is possible some carriers came back on the air that afternoon.

A check at 6:30pm at Mt Kuringai still showed no available 3G signals, and I still couldn't get 3G reception at my home at 6am the following morning.

So it seems that I can expect 3G service for a maximum of three hours after a disaster knocks the power out. Our power was out for 18 hours, so for 15½ hours, we would have been unable to make 000 calls if connected to the NBN by HFC.

I think that the NBN HFC rollout needs to be stopped until a reliable 000 phone service is made available during power cuts.

During this outage, my 'old-fashioned' copper telephone service never skipped a beat and was utterly reliable, allowing us to ring people to find out what was going on and when power might be restored. Will we able to do that once the NBN roll-out is complete? I seriously doubt it.

David Williams,
Hornsby, NSW.

Clipsal dimmer recommended to cure flickering LEDs

Regarding the letter you published titled "LED lights on dimmer flicker periodically", on page 97 of the March 2019 issue, I asked a couple of electrical contractors how to solve this problem, which I was also having. They recommend that I use a Clipsal universal dimmer, which is said to be better than other similar dimmers and does not suffer from the flickering problem.

And regarding the letter on failing motor capacitors on page 14 of that same issue (in the Mailbag section), this is an everyday problem encountered with conventional fan and compressor motors. It does not apply to inverter-driven air conditioners which use the inverter to drive three-phase motors.

Peter Cave,
Ormiston, Qld.

Other uses for Motion-Triggered 12V Switch

I wonder whether Nicholas Vinen realises other uses for his Motion-Triggered 12V Switch (February 2019; siliconchip.com.au/Article/11410). Here are two:

First, I wanted an entry light for my motor camper side door, one that turns off a few minutes after pressing a button. Nicholas' circuit is good for this – just omit the vibration switch S1! The switch S2 is at the entrance; the LED light is the load.

mouser.com

The Newest Products for Your Newest Designs®

FORTE | THE INTELLIGENT BOM TOOL

Master your Bill of Materials
with greater intelligence

- Time-saving, one-step BOM importer (maintains original format)
- Access millions of orderable parts
- Add/delete parts, see multiple quantities and prices
- Part match confidence and design risk indicators

Learn how ***FORTE*** is more than just matching and ordering parts.
Discover why it's what a BOM tool should be at **mouser.com/bomtool**.

MOUSER ELECTRONICS

au.mouser.com
australia@mouser.com

Mouser and Mouser Electronics are registered trademarks of Mouser Electronics, Inc. Other products, logos, and company names mentioned herein, may be trademarks of their respective owners.

Also, I want my UHF radio to turn off after a delay, when the ignition switch is turned off. Nicholas' circuit is good for this – again, omit vibration switch S1. Run an ignition-switched power line (via a diode) to the bottom of S2. The load is the UHF radio.

Now the radio receives power whenever the ignition is on and stays on for a while after ignition is turned off. Further, pressing S2 powers the radio for a while (or extends the time) even with the ignition off.

I made these circuits using a CD4093B Schmitt Trigger device, but Nicholas' circuit would give a similar result in a more compact package.

Peter Manins,
Black Rock, Vic.

USB Port Protector gotcha

Thank you for the excellent kit and well-written constructional article on the USB Port Protector from May 2018 (siliconchip.com.au/Article/11065). I built up the kit, tested it according to the instructions then plugged in a USB drive. It didn't work.

After some disappointment, I figured the fault must be on the data lines (quite a simple bit of the circuit) and started testing with the diode test on my multimeter. I found a dead short across TVS2 both ways. I decided to remove it and test it again. It worked perfectly once TVS2 was removed. I tested the remaining circuit and it was fine.

Looking closely, I noticed that the anode extends all the way under TVS2 and I figured I had installed the item just like all the other surface mount components assuming the middle of the device is insulated. In fact, TVS2 must be placed with a gap between the device and the landing for the cathode with the little lead spanning the gap.

Once I had re-installed it this way, there was no problem. I usually work with through-hole circuitry, so it was challenging and informative to create this little device.

Grant Muir,
Christchurch, NZ.

Nicholas responds: you are right; I hadn't noticed that the anode runs under the device body. Since I provided 'normal' pads for an SMD diode, you are right that it will have to be placed carefully to avoid shorting them out. This device's construction is similar to an SMD transistor (eg, SOT-223) that uses a large tab to transfer heat into the board, but with one lead instead of three.

Dual-gate Mosfets can be used for crystal sets

I was somewhat surprised that you published a crystal set design in the Circuit Notebook section of the February 2019 issue (page 44; siliconchip.com.au/Article/11408).

I have also experimented with a dual-gate Mosfet, the 3SK143. These are also known in the online radio community as a "3DQ" device, although that is actually a batch code. You can order them online in packs of five, at a reasonable cost, but they can take up to two weeks to get here from Asia.

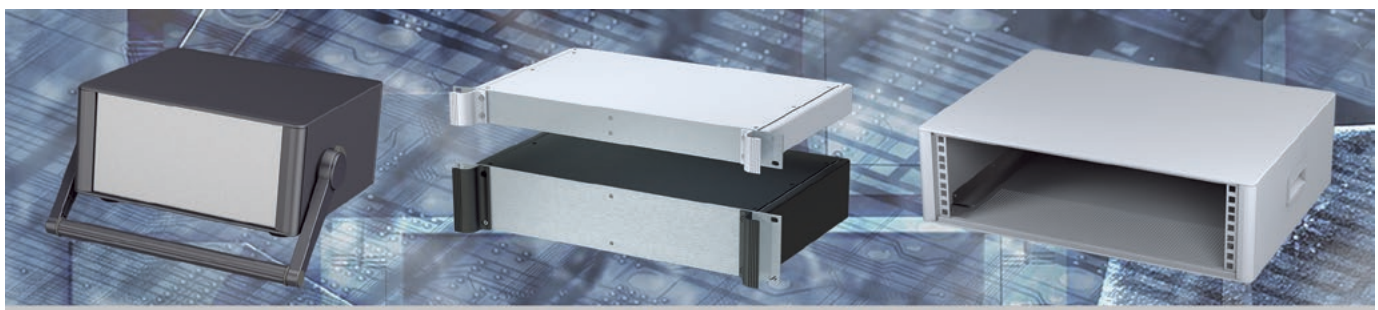
These devices have a high input impedance and a rather low output impedance (500-800Ω) which means that you can drive an efficient pair of earbuds without a matching transformer.

This makes the set compact and also lowers the cost as these transformers can be quite hefty and expensive. I've even built a few into small Tic Tac boxes and the odd matchbox.

These 3DQ Mosfets are small surface-mount devices and are tricky to solder. The best way I found is to use a standard piece of 'doughnut board', which has no tracks on its copper side, only solder lands. The spacing between each land is near perfect for these devices, and you can use some solid core jumper wire to extend your connections to other parts of the set.

The device acts as a synchronous detector, with both gates wired to the top of the antenna coil. The output for the earbuds is taken from the drain. The source is usually connected to a separate coil on the ferrite rod which then connects to the bottom of the antenna coil. This is necessary for output impedance matching. This extra coil needs to be movable along the rod for best adjustment.

You can find suitable circuits by searching online for "3dq circuit". The sets I've built perform really well, bringing in all 12 local AM stations in Brisbane, with only a 10-metre length of multi-stranded CAT4 data cable as the antenna and no ground wire.


ADVANCED ELECTRONIC ENCLOSURES
Modern and versatile aluminium 19"enclosures and instrument cases for today's OEM electronics equipment.
• 19" rack mount cases: 1U, 2U, 3U, 4U, 5U and 6U
• Desktop and portable instrument enclosures
• Highly functional and ergonomic designs
• Full in-house customisation to your requirements
• Download 2D/3D drawings from our website.
Ask for your own fully customised version!

METCASE ENCLOSURES
Phone: +61 2 4722 3388
Email: sales@metcase.com.au
METcase
www.metcase.com.au

Get in touch with the power of ten.

R&S®RTx-K36 Bode plot option now available

Discover the R&S®RTB2000 oscilloscope (70 MHz to 300 MHz):
- 10-bit ADC to see more signal detail
- 10x memory to capture longer time periods
- 10" capacitive touchscreen for easier viewing
- Availalbe with frequency response analysis (Bode plot) option

Oscilloscope innovation. Measurement confidence.
www.rohde-schwarz.com/RTB2000

sales.australia@rohde-schwarz.com

ROHDE&SCHWARZ

The sound through a sensitive rocking armature insert earphone, such as an STC 4T, is not ear-shattering. But the program from some stations can be clearly heard from about 1m away from the earphone.

It would be great if you could design a crystal set around this device, especially if Jaycar or Altronics could produce a kit for it.

It has been quite some time since you last published a project of this nature. Perhaps you could publish one more design while we still have an AM radio band left!

Austin Hellier,
New Farm, Qld.

Significant differences between BWD 216 and 216A

I found the article by Ian Batty about the BWD 216A hybrid bench power supply in the February 2019 issue (siliconchip.com.au/Article/11419) very interesting. I have a BWD 216, serial number 12322. It is based on the LM723 voltage regulator IC and its circuit is very different from that of the 216A published in the magazine.

Until I read the article, I had no idea that the design changed so much between the 216 and 216A.

John Eggington,
Upwey, Vic.

Device for detecting Neutral fault hazard

I refer to Dr David Maddison's letter about the electric shock hazard from water taps, on page 12 of your February 2019 issue. There was a gadget, developed by Tasmanian Networks Pty Ltd, that would make a loud sound if there was a possibility that your house's metal work had become live. It was called the WireAlert.

For houses near the sea, in low lying areas, it's possible for water pipes to take a noticeable share of the return path to the substation. It's only dangerous if there's an inadequate return path for a given load.

The 11-year-old girl received that severe electric shock because the neutral conductor was open circuit, probably due to corrosion at the incoming connection to the house.

The WireAlert could have detected the unusually high source impedance and warned the family.

Paul Smith,
King Creek, NSW.

Comment: that device is also known as the "CablePI". Bizarrely, it is the subject of a safety recall as some units are at risk of overheating and catching fire! They only appear to be available (at no cost) to people living in Tasmania via TasNetworks.

GPS Clock stopping may be due to voltage sag

Regarding the letter on page 110 of the January issue titled "GPS Clock stops at five minutes to 12", I built the version of the clock published in the March 2009 issue and had the same problem on numerous occasions.

I was sure that it was not due to loss of GPS signal (later proven correct), but fresh batteries would get it going every time no matter how good the installed ones were. I tried cleaning the battery connections very thoroughly but the fault persisted.

Fifty years as an electronics tech has taught me to first eliminate the power supply as the problem. So I soldered together two D cells and ran wires to the PCB. MAGIC! That was in March 2016, coming up for three years and not one failure since.

Could it be AA cells drop voltage under some load conditions and the GPS module suffers a loss of power which the program sees as a loss of signal? The two D cells still measure 2.9V. And the clock is very accurate.

Timothy Ball,
Kogarah, NSW.

Response: that's interesting, thank you. You are right that a drop in voltage could explain it, but we wonder why it isn't a widespread problem.

Perhaps you are both using GPS modules that draw more current than the ones used in the original design. Or perhaps the AA cells you're using have a higher impedance than usual.

Serviceman story helped reader with repair

I recently read the Serviceman's Log entry from J. W. of Hillarys, WA regarding the repair on his Yamaha receiver (September 2018, pages 66 & 67). This piqued my interest as I had just received ours back from a tech who had no luck fixing it.

I took the power board to a mate who can test capacitors, and sure enough, the same capacitor that J. W. found faulty was well down in its rating. I quickly purchased a replacement from Jaycar and we are back in business. I had been very close to dumping the stereo, which is a shame as it's a quality unit, despite being pre-HDMI.

This repair saved us the cost of replacing it, which would have been substantial, but even better, it stopped more e-waste from being created. Thanks to J. W. for writing up his fix.

Serviceman's Log and Mailbag are my two favourite sections of the magazine. I am looking forward to more.

Matt Agnew,
Christchurch, New Zealand.

499P9H1

Email : info@philipsmonitors.com.au
Phone : 1300 90 60 47
www.philipsmonitors.com.au

PHILIPS

CABLE ASSEMBLY and BOX BUILD ASSEMBLY

- Metal Work
- Label and Wire Marker
- CNC Engraving and Machining
- Functional Test and Logistic Service

High mix low volume and quick turnaround

Electrical box assembly

Fully automatic cut, strip and crimp machines

AT AMPEC we specialise in manufacturing of custom design cable assemblies as well as turnkey electronic and electric product assemblies.

+61 2 8741 5000
sales@ampec.com.au | www.ampec.com.au

ampec TECHNOLOGIES

AUSTRALIAN DESIGN AND MANUFACTURE
SECURES YOUR IP

- Product design
- Product development
- Software development
- Small scale manufacture
- Equipment repair
- Obsolescence related redesign
- Environmental testing
- Open-air test site
- Data recovery
- Emission analysis
- Secure facility
- Extensive existing product range
- Secure data
- Secure voice
- Covert/LPI communications
- Surveillance products
- Fibre optic

CYPHER
RESEARCH LABORATORIES
U7-10/21 Johnson St, Cairns
Phone: +61 7 4058 2022
Email: enquiry@cypher.com.au

VISIT: www.cypher.com.au

Serviceman's lawnmower modifications could be dangerous

I just read Dave Thompson's Serviceman's Log column on poor designs, in the February 2019 issue. I would like to comment about him adding 10mm of washers to lower the cutting disc of his lawnmower. It may well have worked for him, but before anybody else attempts this, they should consider whether the manufacturer recessed the cutting disc as a safety measure.

Also, keep in mind that this change could affect the balance and vibration of the mechanism, which if upset, could lead to fatigue and possibly disastrous failure. If the disc comes loose because of the added washers, I would hate to think of the consequences.

As for the sandwich maker which needed to be dismantled for cleaning, we had the same problem in my last place of work. I also refused to use it because everybody was too busy to wipe it over after each use. They just used it and left it with crumbs and filling on the plates. I often saw flies sitting on it.

Geoffrey Hansen,
Littlehampton, SA.

Cleaning out the shed before it's too late

I am only a few years from obtaining my OBE (Over Bloody Eighty)! Recently, I received a few directives to "clean out your shed; otherwise, your children will have to do it". That scared me, because the children are complete philistines when it comes to electronics. The thought of my prized possessions being thrown indiscriminately into a skip bin was enough to spur me on!

As I went through my collection, some of the older items brought back plenty of memories. The first and heaviest was one and a half Byer/Rola 66 II, reel-to-reel tape recorder. The half is a transport deck, without the amplifier. These machines were the FJ Holdens of broadcast quality tape recorders.

I then came across two more tape recorders made by EMI. I'm not sure of their exact model number, either L1 or L2. These came to me from a Melbourne station about 1970.

These were an early portable machine, battery operated, enclosed in a wooden case (like the Rola machines), with a 4-inch tape and I presume it ran at 7½ IPS (inches per second).

I also found two 16-inch Australian-made Byer turntables. I believe these were something of an industry standard to play long programs on large 16-inch discs at 33RPM, before tape became the standard for distribution of nationally distributed program material.

I then came across two National 12-inch turntables that I purchased around 1963. They were well built from pressed steel, and rather pleasing to the eye, with a standard engineering rubber drive wheel to the inside rim of the turntable.

They had an innovative speed variation control, built like a disc brake system. On the bottom of the stepped capstan drive for the fixed speeds was a steel disc 70-80 mm in diameter.

The speed variation was simply a magnet that would swing over the disc exerting drag, and depending on how far you extended the magnet, it slowed accordingly.

I also found, in a cupboard in the shed, two Reslo ribbon mics. One is working; the other needs a new ribbon. The ribbon is mounted within a frame, like a tiny picture frame, and then the frame is placed securely so that the ribbon is in the magnetic field.

Ribbon mics have faded out of use in radio broadcasting but they have been well replaced by low impedance, dynamic uni-directional equipment. Then I found some J. S. (Jørgen Schou), type 0.32, No. 251 audio transformers which sell for $500-2000 on various sites.

That just about covers the first wave of sorting all the big and obvious things. There will be more smaller treasures such as a BA tap with nuts and bolts and some 1/8-inch Whitworth, which I can't use with aluminium because they are brass. There's also a 5/8-inch tap and die, brass thread, for making extra microphone stands from extruded aluminium or electrical conduit.

The three and a half tape recorders (as mentioned earlier) are free to a good home; anything with commercial value, I'll try to sell. The rest of my treasures I will happily give away to a young person who has shown an interest in all things electronic.

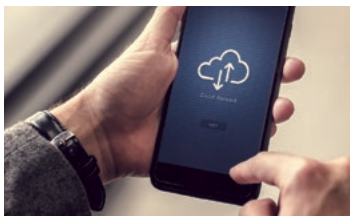
I started reading "Radio, TV and Hobbies" magazine back in the 1960s. I paid two shillings and six pence for each copy! I still remember Neville William's article on how CD players worked. Later electronics magazines, up to and including SILICON CHIP, have kept me informed and challenged.

Over the years I have made lots of preamps, power amplifiers, various mixers and distribution amps. There is still a buzz for me when having built a small amp and connected it up, a clean sound comes out!

Ken Ewers-Verge
Albany, WA.

Out of the Box and Into the Cloud in 30 Seconds

Securely Connect Your Device to the Cloud with the AVR-IoT WG Development Board



Our new rapid AVR-IoT WG Development Board enables you to prototype connected devices within minutes. The solution combines a powerful AVR® microcontroller (MCU), a CryptoAuthentication™ secure element IC and a fully certified Wi-Fi® network controller on a single board providing a simple and effective way to connect embedded applications. Once connected, Google Cloud IoT Core makes it easy to collect, process and analyze data to inform decisions at scale.

Key Features

- Self-contained IoT sensor node; combining smart, connected and secure devices on a single board
- Designed for battery-powered applications with an 8-bit MCU and secure element with extremely-low power consumption
- Devices come pre-registered on Google Cloud IoT Core and are ready for use with zero touch provisioning

Contact Information
Microchip Technology Australia
Email: aust_nz.inquiry@microchip.com
Phone: +61 (2) 9868-6733

microchip.com/AVR-IoTWG

SMART | CONNECTED | SECURE

MICROCHIP

The Microchip name and logo, the Microchip logo and AVR are registered trademarks and CryptoAuthentication is a trademark of Microchip Technology Incorporated in the U.S.A. and other countries. All other trademarks are the property of their registered owners.
© 2019 Microchip Technology Inc. All rights reserved.

Wagner
ELECTRONICS SUPER STORE
OVER 40 THOUSAND PRODUCTS
ONLINE 1500+ PAGE CATALOGUE
AUSTRALIA WIDE SHIPPING

AUDIO/VISUAL ACCESSORIES
SPEAKERS / PRO AUDIO
ELECTRONIC COMPONENTS
DATA & ELECTRICAL
TOOLS & TEST EQUIPMENT
BATTERIES & MORE!
BUY ONLINE AT
WAGNERONLINE.COM.AU
VISIT OUR SYDNEY STORE
84-90 PARRAMATTA ROAD,
SUMMER HILL, NSW 2130
02 9798 9233

Comments on DIY weather station idea

In the Mailbag section of the August 2018 issue (page 13), Bruce Pierson suggests a complete weather station project.

I agree with him on this; It doesn't have to be any harder than most other electronics projects and would be far more fun and configurable than buying a $200 one on eBay.

There are many low-priced rain gauges, wind speed and direction sensors out there to use without having to make them. Also, consider the many varieties of temperature/humidity/pressure sensors (the BME280 for example) along with the trusty DS18B20 for remote temperature.

It could be designed with the possibility of future expansion, eg, additional displays, data logging, a real-time clock or GPS time support, remote sub-stations etc.

There is a project called "WeatherDuino" which you can find on the internet. Maybe you could create an Aussie version of that.

Peter Richardson.
Bribie Island, Qld.

Response: we published a series of articles on a weather station based on the WeatherDuino, the WeatherDuino Pro2 Wireless Weather Station, in the March-June 2015 issues. See: siliconchip.com.au/Series/285

See also our article on the BMP180 and BMP280 (which is similar to the BME280 which you mentioned), in the December 2017 issue (siliconchip.com.au/Article/10909).

Building the DDS Signal Generator

I recently build your Micromite BackPack-based DDS Signal Generator (April 2017; siliconchip.com.au/Article/10616).

I have noted the addition of three RCA connectors in the parts list in errata published in the February 2018 issue. I also noticed that there is a 560Ω resistor listed in the parts list which should be 470Ω, to match the circuit and wiring diagrams.

The article mentions the possibility of substituting BNC connectors for the specified RCA connectors. I have chosen this option on my build but I found it a bit tricky.

Since BNC connectors project further into the case than RCA connectors, the top panel with the BackPack board attached must be rotated 180° so that the greatest clearance between

the board and the connectors can be achieved.

There is just barely enough room to clear the components. See the photo above of my complete unit.

More separation is also required between the BNC connectors to allow human fingers to secure the plugs when in use. To provide the separation, I mounted the x1 and x0.1 sockets as far apart as possible, close to the top panel, while the trigger input connector is centrally located between these and towards the bottom of the case.

Note that instead of purchasing ready-made flying leads (Jaycar WC6026 or Altronics P1017), I purchased Pololu 900 0.1" connector housings and Pololu 1930 0.1" female crimp pins from Core Electronics (https://core-electronics.com.au/) and made the leads to suit. Of course, to do this one must have a suitable crimping tool.

Ross Herbert,
Carine, WA.

Comments on the January issue

The Editorial Viewpoint in the January 2019 issue of SILICON CHIP is a statement of the reality – hobbyists must be prepared to use tiny surface mount components. I had to face up to this fact some years ago and can hand solder discrete components and ICs with pin pitches of 0.4mm without problems.

However, DFN and QFN type ICs presented a problem. My solution was to glue the IC upside down onto the PCB and attach wire wrap wire to the pads in the same manner as the manufacturers connect silicon dies to the leg pads of an IC package. The only difference is that I solder the wire to the pads and they weld the wires to the die pads.

This method naturally flips the pin configuration and I have to design my PCB layout accordingly.

However, this could be used even

with veroboard and similar. All you need is some wire wrap wire (Kynar), fine solder and a fine tipped soldering iron.

In the Mailbag section of that issue, Cameron Wedding requested that a high voltage linear power supply should be considered as a project. It is a good idea.

Please consider using two 12V-30V 6A transformers. The tappings could be switched into and out of the circuit to provide a broad range of voltage and current combinations with minimal power loss and heating.

I enjoyed the 3D printing article by Dr Maddison in the January 2019 issue of Silicon Chip. It is not something of great interest to me but even so, it was an excellent overview of the technology.

I had no idea of the types and capabilities of 3D printing equipment. From someone who designed complex pieces of equipment, there were quite a number of my designs that could have been prototyped using 3D printing. However, I must express caution about the technology.

I have watched a machining station produce a very intricate part in about a minute with a resultant cost of about $5. There is no way that a 3D printer will match that and I am quite sure the same would apply to injection moulded parts. Without a doubt, 3D printers will find a niche in industry but they are not going to displace some of the current technologies.

I also liked the article by Jim Rowe about stepper motors but there are a few things that he did not mention. One is the ratings of the motors. Many of the motors that I have used have been rated at around 2V and 2.5A. This voltage is not the driving voltage of the motor but the maximum DC drop across each winding. The current rating is the maximum permitted winding current.

I have used several supply voltages with stepper motors from 5V to 24V but I have seen supplies as high as 80V used. The reason is speed.

With motors stepping at thousands of steps per second, the magnetic fields in the poles must go from zero to maximum and back to zero in a very short time and that requires high applied voltages.

In the earlier days, the current was limited using constant current drives or simply resistors but that method is very wasteful. The efficient method is to use switchmode type drivers. I have used the LMD18245T from National Semiconductor and the MTD2003 from Shindengen but now use the Allegro driver, A3979 and can recommend it.

The only catch is that the IC has an exposed die which must be bonded to the PCB for heatsinking. However, Allegro make a 750mA SOIC packaged driver which would handle most hobby applications. It is designated A3967 and the data sheet has some useful information about switchmode stepper motor drivers.

While Jim showed a variety of motor types (I have used almost all of them), there is one that is missing. It is a linear stepper motor. I have two of these and they were removed from 15-inch printers of IBM manufacture. I have never seen them in any other equipment and I keep them as curiosities.

The PicoPi Pro Robot article in the January 2019 SC is a nice design. It is still in the class of robots that I refer to as sugar coated but it has a very redeeming feature and that is the choice of microcontroller. Both the PIC16F505 and the PIC16F506 are mentioned but it is the use of the 505 which I like.

It is a simple microprocessor, like the good old Z80. It is a good choice for beginners to learn on. One of its great features is that it shares a common pin pattern with quite a few other microcontrollers.

George Ramsay,
Holland Park, Qld.

Origin of the Useless Box

In reading the description of the "Useless Box" in your December issue (siliconchip.com.au/Article/11340), I noticed its similarity to Claude Shannon's "Ultimate Machine". Maybe I missed it, but I expected someone to comment and give Shannon a mention.

Peter Dare,
New Zealand.

Comment: we had not heard of Claude Shannon or the Ultimate Machine. This is an idea which has been floating around for a while. According to Wikipedia, the first "useless box" was made by Italian artist Bruno Munari in the 1930s, and the idea was then picked up by Marvin Minsky of Bell Labs/MIT in 1952. That was apparently where Claude Shannon, also at Bell Labs, got the idea. SC

OCEAN CONTROLS

Helping to put you in Control

ITP11 Process indicator (Red)
Easy to mount the ITP11 fits into a standard 22.5 mm borehole for signal lamps and can be connected to any transmitter with a 4-20 mA output. The measured values are scalable and there is also an optional square root function.

SKU: AKI-001
Price: $119.95 ea + GST

PR200 Programmable relay
Features 8D1+8D0+4AI+2A0. Includes LCD and Function buttons. Easy to Program Function Block Software.

SKU: AKC-001
Price: $399.95 ea + GST

Ursalink 3G SMS Controller
Budget priced 3G SMS Controller. It has 2 digit inputs and 2 relay outputs. SMS messages can be sent to up to 6 phone numbers on change of state of an input and the operation of the relays can be controlled by sending SMS messages from your mobile phone.

SKU: ULC-001
Price: $224.95 ea + GST

8 Digit LCD Meter
LCD Meter for Rotation speed / Frequency measurement. Battery powered, IP66 Front panel protection.

SKU: HNI-102
Price: $64.95 ea + GST

AC Volts/Current Indicator
A budget priced 4 Digit Process Indicator(48 x 96 mm) with 0-500VAC/0-50VAC/0-5Aac/0-1Aac Input, Alarm relay output and 24 VDC Powered.

SKU: DBI-032
Price: $149.95 ea + GST

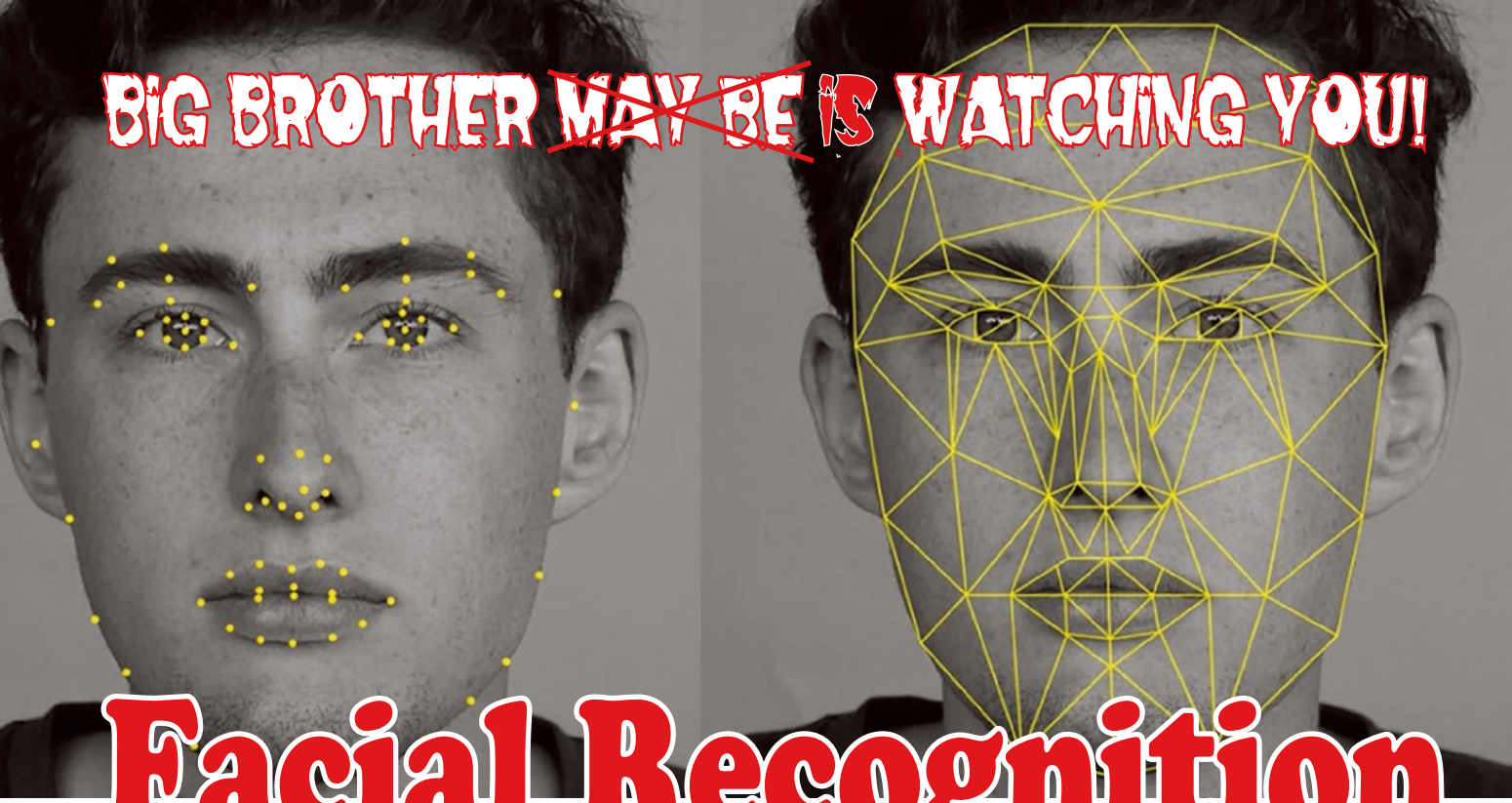
Loop Powered Temperature Sensor
This is a simple 4 to 20 mA output loop powered temperature sensor with measurement range from -10°C to +125°C designed for monitoring RTU and PLC cabinet temperatures.

SKU: KTD-267
Price: $54.95 ea + GST

Temperature Sensor Wall Mounted
100 mm probe Pt100 RTD sensor with standard head. 3 wire connection and room in the head for a signal conditioner.

SKU: AKS-001
Price: $59.95 ea + GST

For Wholesale prices
Contact Ocean Controls
Ph: (03) 9708 2390
oceancontrols.com.au
Prices are subjected to change without notice.



Facial Recognition

Have you ever had that feeling that "someone is watching you"? You're not being paranoid . . . because the chances are that someone, somewhere is doing exactly that – from social media apps to government/law enforcement surveillance systems and possibly even by criminal enterprises. And while serious privacy concerns have been raised, facial recognition is also a useful tool for fighting crime and terrorism.

by Dr David Maddison

AS **the name suggests, facial recognition** is where a computer or hardware device determines the unique characteristics of a person's face, based on still images or video, to identify them.

In today's world of widespread terrorism, identity theft, criminal activity and online socialising, its use is becoming widespread.

In many cases, people's photos are available on the internet – whether they want it or not. Some people may not even be aware of it.

These photos can be fed into facial recognition software and used to identify and even track individuals, whether by government organisations or third parties.

Apart from law enforcement and social media applications, modern smartphones such as the iPhone X, Galaxy Note 9 and LG G7 can use facial recognition to automatically unlock the device for its owner and prevent use by others.

Commercial organisations such as casinos also use facial recognition to enforce bans against specific individuals and for other reasons, which will be discussed later.

Facial recognition comes under the heading of biometric systems, just like fingerprint or iris recognition.

But unlike most other biometric systems, it can be performed without the knowledge or even cooperation of the subject and is amenable to mass surveillance due to the huge number of cameras already installed around the world.

Use in Australia

Controversially, it is likely that the Australian Government will soon have in place a national facial biometric matching capability with images of a substantial number of Australians.

These will be "harvested" from passports, driver's licenses, citizenship documents and visa applications as well as presumably any number of other sources of opportunity.

Various states and government agencies already have their own systems in operation but the proposed system will integrate these and other systems on a national basis. See siliconchip.com.au/link/aan8 and siliconchip.com.au/link/aan9 for more details.

The Government system will be known as "The Capability" – not a sinister name at all! See: http://siliconchip.com.au/link/aana

Facial recognition systems require large amounts of computer power to be used in real time; hence, it is only with

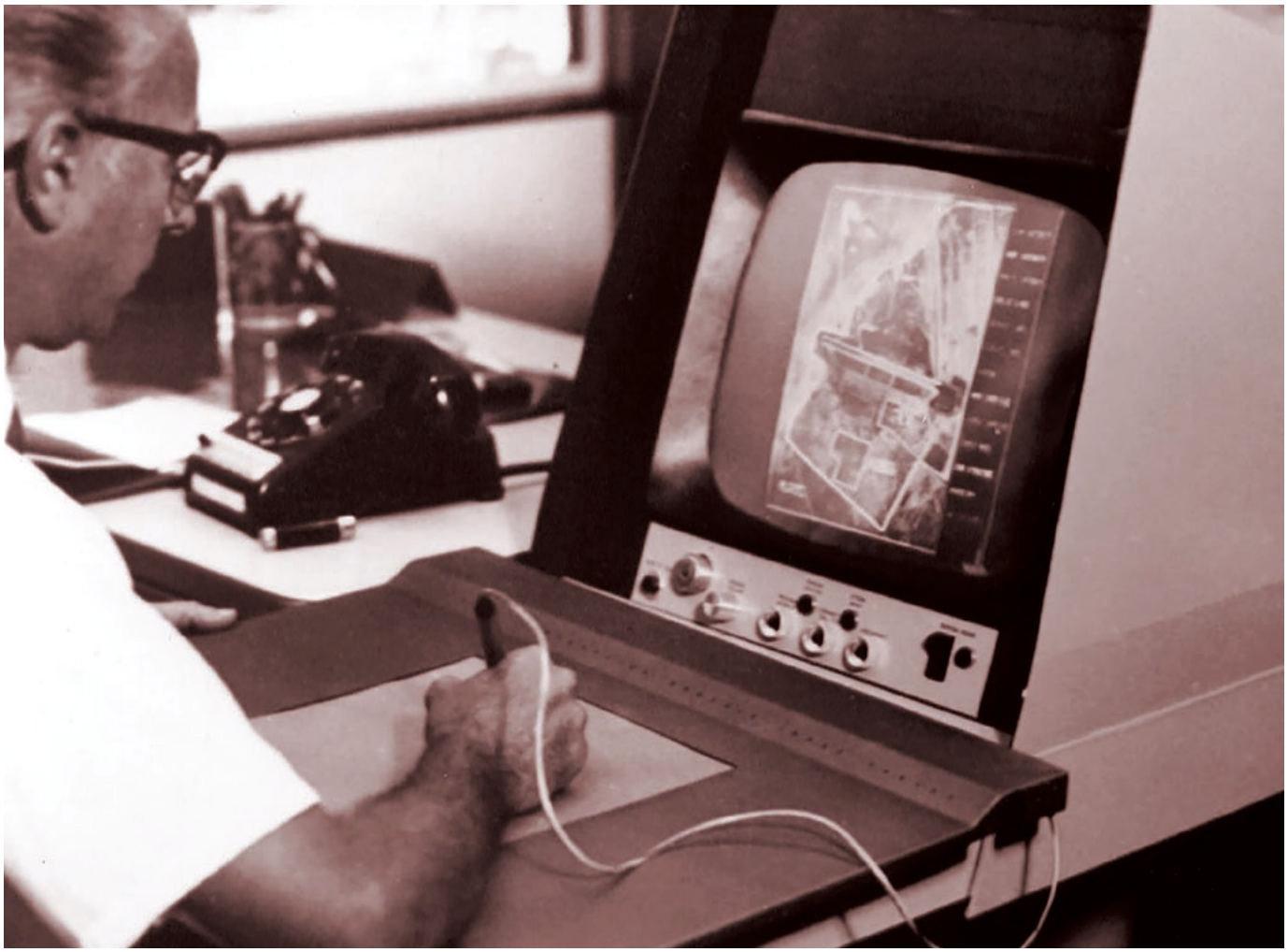


Fig.1: a RAND tablet from the 1960s which allowed the human operator to input facial landmarks into a computer database. The digitising surface was approximately 25cm x 25cm with one million possible locations. One operator could process about 40 photos per hour. Little was published on this work, due to it having been funded by the US Government (DARPA). It also had other uses, as seen in this photo. (siliconchip.com.au/link/aanf)

the development of sufficiently fast and cheap computers in the last 15-20 years or so that these systems have become practical and commonplace.

It has also been necessary to develop appropriate computer algorithms to perform the task of facial recognition. This is an ongoing task.

Facial recognition involves one of the most challenging problems in computing and artificial intelligence, which is visual pattern recognition. This is something that humans do easily and intuitively – it is built into our brains from birth.

We can easily recognise a familiar face, even with only a partial, non-frontal view under poor lighting conditions for a very brief moment.

But that is a difficult task for a machine.

Early photograph-based systems

Facial recognition of sorts has origins back to the time when cameras became widely available, around 1839.

Prisoners in Belgium were photographed as early as 1843 and in some parts of England, prisoners were photographed from 1848, so that they could be more easily found if they escaped.

The Pinkerton National Detective Agency, a private detective agency established in the USA in 1850 (and still in existence), also photographed people it apprehended.

At the time, the alternative to a photograph (which too had its critics in Victorian society) was to brand certain convicted criminals who had committed serious offences.

Otherwise, it was tough to identify known criminals. Before photographs, this was usually done by written descriptions or direct testimony of victims or police.

For a discussion on photographing prisoners, see siliconchip.com.au/link/aanb

Alphonse Bertillon was a French police officer and early biometrics researcher who invented a system of physical measurements to enable police to identify a criminal objectively.

He also developed the “mug shot”, the technique for which was standardised in 1888.

Bertillon noted the difficulty in searching a collection

Google reverse image search

If you have a link to an image online or a saved copy of that image, Google can often find other exact or similar copies of that picture online and also possibly identify the people in the image. Go to https://images.google.com/, click on the camera icon and use “&imgtype=face” in the query.

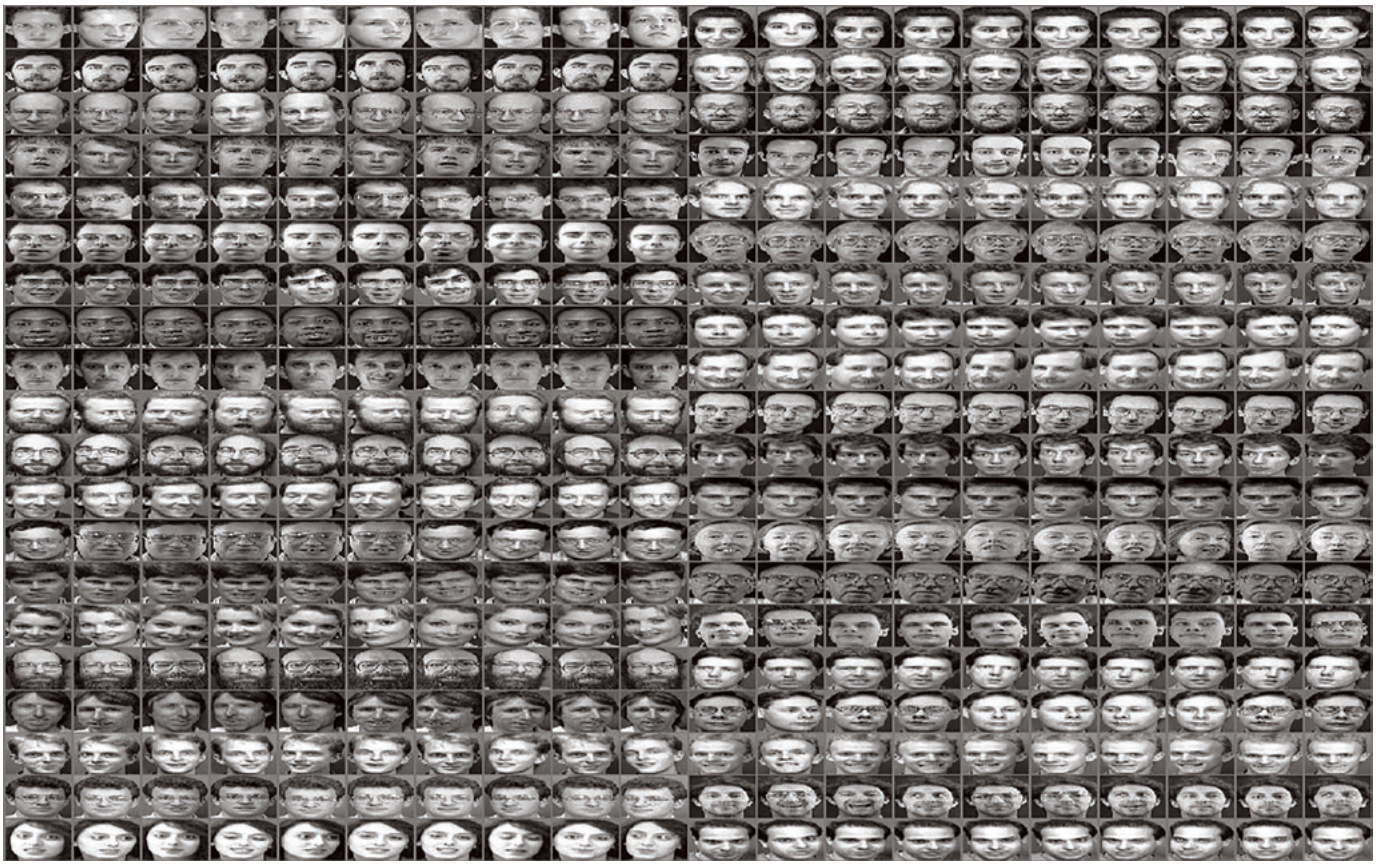


Fig.2: a collection of faces known as the AT&T "Database of Faces", which is a standard set used for testing and research by people working in the facial recognition field. It consists of 10 pictures of each of 40 people.

of photos with no other criteria applied. He said that it was hard to identify an individual "if you have no other means but your eyes to search for the photograph among the thousands in an ordinary collection".

Early computerised systems

Modern computerised facial recognition systems have their origins in the 1960s, with the first work carried out by Woodrow W. Bledsoe with Helen Chan and Charles Bisson during 1964-1966 at Panoramic Research in Palo Alto, California.

In this work, an early digitising device known as a RAND tablet (Fig.1) was used by a human operator to mark the location and size of various facial landmarks of a person on photographs.

This included the eyes, nose, mouth and hairline. These locations were then compared with the locations stored in a database and the closest match was used to identify the person.

This early system was limited by the lack of computer power and memory storage of that time but was an important first step to prove the viability of the technology.

Following Bledsoe, in the 1970s, Goldstein, Harmon and Lesk used 21 subjective facial markers such as hair colour

False facial identifications and overall accuracy

Facial recognition software is not perfect, far from it, and a bad identification can ruin someone's life, as explained in the article at: **siliconchip.com.au/link/aane**

Accurate facial recognition is very much dependent on the quality of the original picture(s) stored in the database, including conditions such as lighting, orientation toward the camera, facial expression etc.

There's also the question of just how useful it is, even when it works. Critics have made the argument that in places like the United Kingdom, where there is widespread surveillance and facial recognition technology in use, no (or few) criminals or terrorists have been apprehended specifically due to these systems.

Fig.3: the set of eigenfaces computed from the AT&T Database of Faces shown above. In this case, principal component analysis mapping has been computed and the first 24 principal components (eigenfaces) are shown. These eigenfaces can be added together in various proportions to recreate all the original faces with little loss of accuracy.

Fig.4: reconstructing a photo of one person by combining Eigenfaces computed from the AT&T Database of Faces using the OpenCV software.

and lip thickness to achieve greater recognition accuracy. But the facial features still had to be manually entered into the computer.

In 1987, mathematicians L. Sirovich and M. Kirby developed an approach to efficiently represent facial images using principal component analysis (PCA).

This was used as the basis of facial recognition by computer scientists Matthew Turk and Alex Pentland in 1991.

PCA is a statistical technique whereby a large number of possibly correlated variables are reduced to a smaller number of non-correlated variables.

While the resulting set of variables is significantly smaller than the starting set, it still contains most of the same information. In other words, it is a method of "lossy" data compression, or dimensionality reduction as it is also known.

The first principal component accounts for most of the

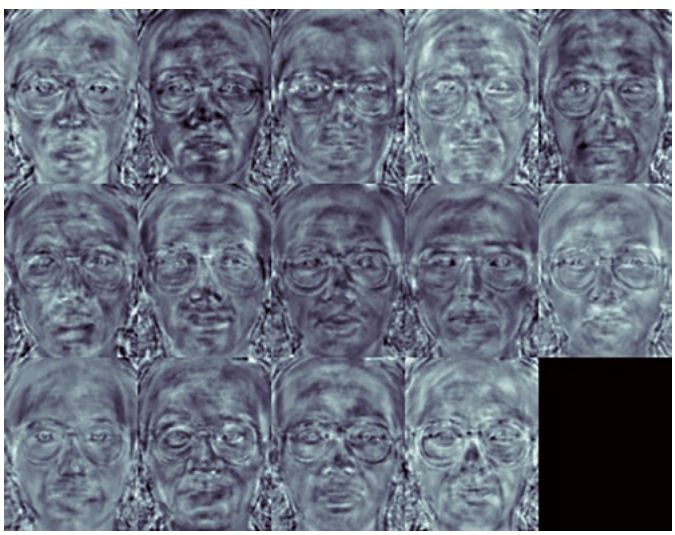


Fig.5: a selection of Fisherfaces from Yale Face Database A, computed by OpenCV.

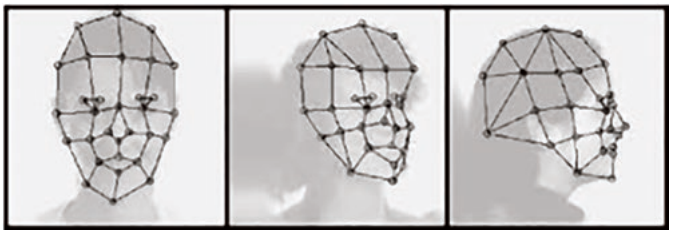


Fig.6: elastic bunch graph mapping showing a subject in three different poses.

variability in the data set, the second accounts for most of the remaining variability and so on. Principal component analysis as applied to human faces results in a set of images known as eigenfaces (Fig.3).

In practice, relatively few principal components can account for most of the variability of human faces (Fig.4). This technique dramatically simplifies data processing as much less data needs to be stored and compared.

Sirovich and Kirby determined that a large collection of facial images could be simply represented by a small set of "standard" faces (eigenfaces) to which are applied weighting factors to approximately represent all members of the collection.

Eigenfaces might also be thought of as "standardised face ingredients" and any human face can be considered a combination of various proportions of these standard faces, eg, an individual might comprise 10% of eigenface #1, 16% of eigenface #2 etc.

Relatively few eigenfaces are needed to represent all human faces, as long as the appropriate mix of each is applied. For example, combinations of 43 eigenfaces can be used to represent 95% of all human faces.

Turk and Pentland essentially applied the inverse of Sirovich's and Kirby's work (a way to represent known faces) to identify unknown faces. Their technique took unknown faces and determined what weighting factors needed to be applied to generate the features of a known individual in a database (eigendecomposition).

The closer the weighting factors were between the known

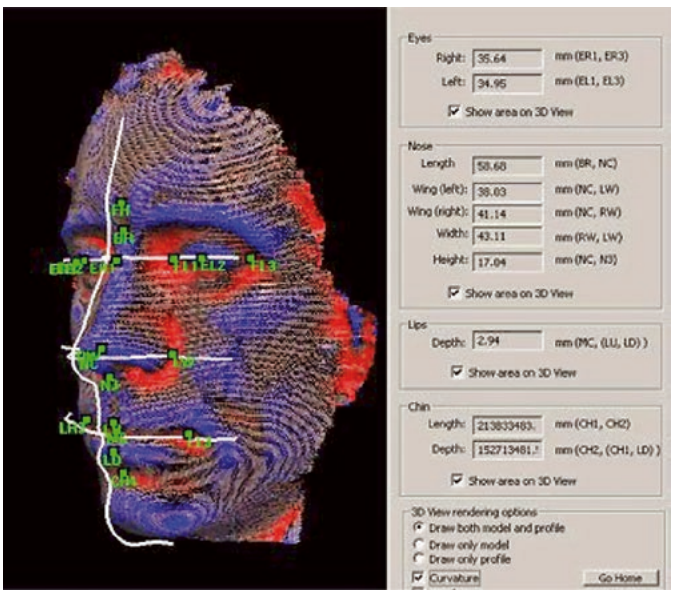


Fig.7: a faceprint of a test subject for Aurora 3D facial recognition software.

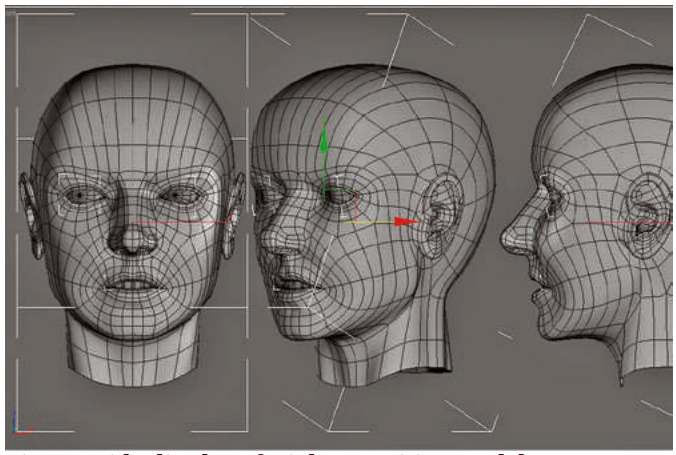


Fig.8: an idealised 3D facial recognition model as seen from various angles. With a 3D model, a face can be recognised from many different angles, not just from straight ahead or with a slight deviation from straight.

face in the database and those calculated from the unknown, the more likelihood there was of a match between the unknown and known face.

The computer code to calculate eigenfaces is relatively simple to implement in software such as Matlab, as shown in the following example, which uses the facial database "yalefaces".

There is also a video explaining the technique of principal component analysis and eigenfaces titled *"Lecture: PCA for Face Recognition"* at siliconchip.com.au/link/aaoe

```
clear all;
close all;
load yalefaces
[h,w,n] = size(yalefaces);
d = h*w;
% vectorize images
x = reshape(yalefaces,[d n]);
x = double(x);
% subtract mean
mean_matrix = mean(x,2);
x = bsxfun(@minus, x, mean_matrix);
% calculate covariance
s = cov(x');
% obtain eigenvalue & eigenvector
[V,D] = eig(s);
eigval = diag(D);
% sort eigenvalues in descending order
eigval = eigval(end:-1:1);
V = fliplr(V);
% show mean and 1st through 15th principal
  eigenvectors
figure,subplot(4,4,1)
imagesc(reshape(mean_matrix, [h,w]))
colormap gray
for i = 1:15
    subplot(4,4,i+1)
    imagesc(reshape(V(:,i),h,w))
end
```

More advanced facial recognition

From 1993 to the early 2000s, the US Defense Advanced Research Projects Agency (DARPA) and the National Institute of Standards and Technology (NIST) developed a facial database called FERET that eventually consisted of 2413 24-bit colour images of 856 different people.

Fig.9: Apple's iPhone X uses its TrueDepth front-facing 3D camera to illuminate a face with a pattern of 30,000 infrared dots which are then converted to a 3D facial model. The system is highly accurate and in tests could not be fooled by identical twins; it would only unlock the phone for the twin to whom it was authorised.

Its purpose was to establish a large database of images that could be used for testing facial recognition systems.

Controversially, in 2002, the US Government used facial recognition technology at that year's Super Bowl (American Football grand final).

Several petty criminals were detected but the test was seen as a failure, as the technology of that time did not work well in crowds.

This also led to concerns over the civil liberties implications of such technology.

Facebook started using facial recognition technology in 2010 to identify users who appeared in photos posted to the site by other users. Google Photos and Apple Photos have now deployed similar technology.

Facial recognition is now also used in airports and border crossings around the world, and by law enforcement agencies.

Steps for facial recognition

For software systems to recognise a face, five main steps must occur. These are:

1. Detection of a human face in a still or video image (which may have a cluttered background).
2. Alignment and normalisation of the face to a standardised position with even illumination.
3. Representation of the normalised image with an appropriate mathematical pattern.
4. Feature extraction to determine those characteristics that are unique to the face and at variance to an "average" face.
5. Searching a database of known faces for a match using these characteristics or variances.

Common problems in facial recognition are:

1. A differing facial expression, pose or angle to that in the database.
2. Differing or uneven illumination.
3. Ageing of the subject or changes to hairstyle, hair colour etc.
4. Low size or poor quality of the image.
5. Additions or deletions of items such as facial hair,

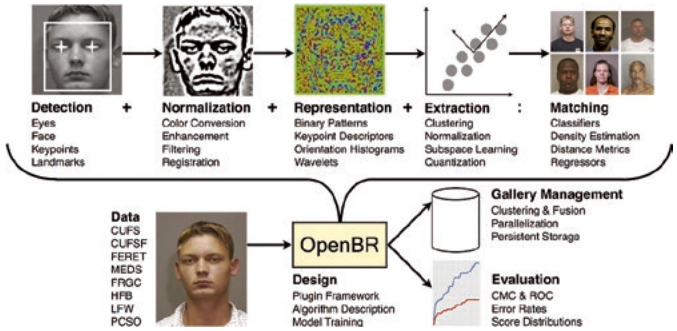


Fig.10: how OpenBR works. It is an open-source biometric software framework for facial recognition (http://openbiometrics.org/) OpenBR can use a variety of different facial recognition algorithms such as PCA (principal component analysis), LBP (local binary patterns), SVM (support vector machines), LDA (linear discriminant analysis), HOG (histogram of oriented gradients) and more.

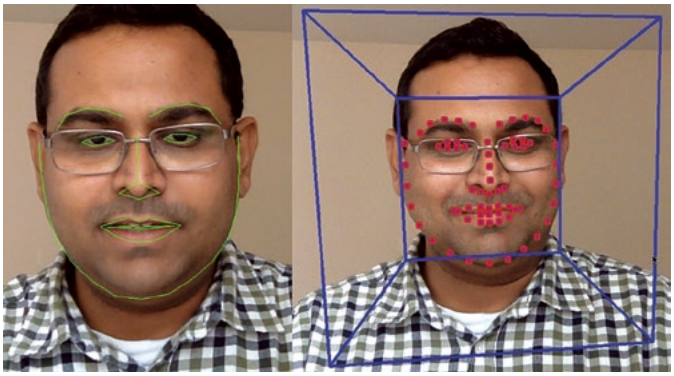


Fig.11: OpenCV is an open-source software library for computer vision which includes the ability to perform facial recognition (https://opencv.org/). In this example, facial landmark detection is being used with two different techniques. On the left, it is using Dlib and on the right, CLM-framework. The blue lines represent the direction of gaze of the face, which it also detects. See the video titled "Facial Landmark Detection" at siliconchip.com.au/link/aaod for more information.

glasses, scarves or other objects disguising part of the face or surrounds.

Statistical facial recognition techniques

The principal component analysis and eigenfaces technique developed by Turk, Pentland, Sirovich and Kirby mentioned above is still in use today in facial recognition systems.

But many other techniques have now also been developed. The eigenface approach has an accuracy of about 90% with frontal face images, assuming good lighting and an appropriate pose, but is very sensitive to those factors.

There are two main approaches to facial recognition. These are so-called template-based methods and geometric-feature based methods.

Template-based methods utilise the whole face and extract features from the full face image, which are then matched to an existing face in a database using a pattern classifier algorithm.

Geometric-feature methods locate specific landmarks on the face such as the location of the eyes, nose, chin etc and determine the geometric relationship between them, or alternatively and more recently, match a three-dimensional image of a face to a stored representation.

Template matching techniques require an image or a set of images of a person's face. The facial features are then extracted via a mathematical process and a unique "template" for that face is produced.

With the eigenfaces described above, this can result in as little as 2-3kB of data per face.

This allows vast numbers of templates to be searched in short amounts of time to find matching faces, at rates of perhaps 100,000 faces per second. So searching a database of all Australian residents for a match could take less than 300 seconds with a modest computer system.

Template-based methods can be divided into the following categories: statistical, neural network, hybrid methods (which incorporate both) and other methods. Statistical methods are the most common.

Of those statistical methods, PCA and Linear Discriminant Analysis are very popular. Other statistical tools include Independent Component Analysis , Support Vector Machines and kernel methods for PCA and LDA.

Geometric techniques

Of the geometric methods, elastic bunch graph matching is a common method. PCA was also developed into Local Feature Analysis.

Fisherfaces (Fig.5) are used with the LDA statistical technique and they are similar to the eigenfaces used with PCA.

LDA is less sensitive to lighting variation and facial expressions than PCA and is said to be more accurate overall, but it is computationally more intensive (ie, searching a similarly sized database takes longer).

EGBM works similarly to the processes that occur in the human brain when recognising a face. To create a facial model for the database, facial landmarks are determined and nodes are created at these points and joined to one another.

The result is a graph, akin to a spider's web, over the face.

Landmarks might include points such as the centre of the eyes, tip of the nose, chin etc. This process is usually carried out with images of multiple different poses.

To work well, this method requires facial landmarks to be accurately located, a process that can be assisted by the use of PCA and LDA methods. When it is required to identify an unknown face, the database is searched for the most similar geometric model.

Three dimensional (3D) facial recognition is another example of a geometric facial recognition method (see Fig.6). This method records a three-dimensional scan of a subject's face (known as a "faceprint"; see Fig.7) and uses that to make an identification.

It has the advantage that, because it is comparing 3D shapes instead of 2D images, there are no problems that arise from uneven lighting, differing facial orientation, facial expression, makeup etc. 3D images of a face can also

Using DNA evidence to reconstruct an unknown face

In theory, it is possible to use traces of a criminal suspect's DNA to reconstruct an image of their face. Already it is possible to determine eye, skin and hair colour from DNA but in the future, DNA phenotyping is said to be able to predict the appearance of a face. A website at which users can predict eye, skin and hair colour from a DNA sequence is at: https://hirisplex.erasmusmc.nl/

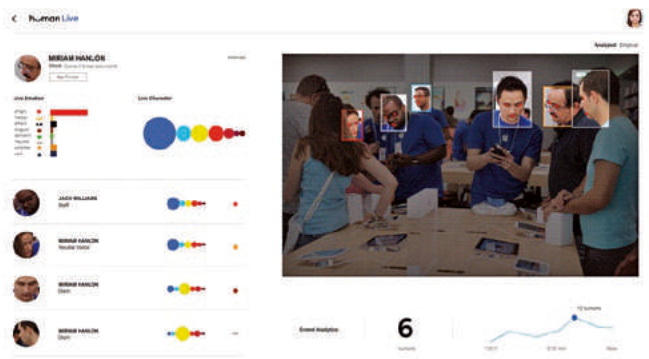


Fig.12: the output from Human's software, showing specific identified individuals and their real-time emotional states, including a ranking for such parameters as angry, happy, afraid, disgust, consent (?), neutral, surprise (!) and sad.

be used to generate a 2D image in a specific orientation, to match with photographs in the database that were taken with a similar orientation (see Fig.8).

Three-dimensional facial recognition has a high level of accuracy, equivalent to fingerprint identification, but one drawback is that it's much more difficult to acquire data for the 3D facial database as people are likely to have an aversion to having their face "scanned", compared to having a simple photograph taken.

Nevertheless, the technique is making inroads and is used in the new Apple iPhone X (Fig.9). See the video titled *"Using An Infrared Camera To Show How Face ID Works"* at **siliconchip.com.au/link/aaob**

Skin texture analysis is a supplemental process to facial recognition. A picture is taken of a section of skin and any distinguishing lines, skin pores and texture analysed and reduced to a mathematical identifier. An example of measurements taken might be the size, shape and distance between pores and/or lines.

This technique can improve the accuracy of face recognition alone and can help distinguish between identical twins.

Uses for facial recognition

There are diverse uses for face recognition, both now and in the future. Among these (in no particular order) are:

- access control to facilities, computers or mobile devices
- for blind people to recognise friends and family
- for finding relevant photos on social media platforms
- border security
- police use
- intelligence agency use
- military use (eg, identifying terrorists)
- identification of unknown people in historical photographs
- finding pictures of known people in collections of photographs

Use by casinos

Casinos were early adopters of facial recognition technology for a variety of reasons, including the ability to exclude banned individuals from their establishments, including known "card counters".

Card counting is a gambling technique banned by casinos worldwide as it improves the chances of the gambler to win against the house. Another use is to identify gamblers that make too many winning bets so they can also be excluded from the premises in future.

Fig.13: the use of facial recognition in China is extensive and advanced. This image comes from Chinese company Megvii (https://megvii.com/) who combine artificial intelligence with their facial recognition technology. This shows Face++ which can detect faces within images; mark 106 facial landmarks; determine face-related attributes including age, gender, emotion, head pose, eye status, ethnicity, face image quality and blurriness; compare two facial images and provide a confidence score as to whether they are the same face or not; and search a database for a match.

A more recent development of facial recognition in casinos is to use software that can determine a gambler's emotional state, including feelings of anxiety and depression, by analysing subliminal, involuntary facial expressions. These may only last for milliseconds and usually are not noticed by other people (Fig.12).

This software is provided by artificial intelligence start-up Human (**https://wearehuman.io/**). In casinos, it is said to be used to identify problem gamblers as a matter of social responsibility.

The CEO of Human, Yi Xu said: "The ongoing scanning of people's emotions and characteristics in casinos and other gambling environments has provided our clients with the ability to flag any extreme highs and lows in players' emotions, for example, if a player is gambling irresponsibly or while distressed".

Human's software also has another interesting application. It can be used by poker players to improve their "poker faces" by helping them to train to eliminate any non-verbal cues they may inadvertently give to other players.

Beyond the casino, Human's software can also detect whether someone is lying, disagreeing, nervous or passionate. Applications include identifying the best candidates for a job, minimising human bias, understanding customer feelings and predicting human behaviour by understanding their feelings.

Use by the government of China

China's government makes widespread use of surveillance, with street cameras spread throughout their cities (Fig.13). The national surveillance system is known as "Xue Liang", or in English, "Sharp Eyes". This network is used for crime prevention but could also be used to track political activists or even to enforce their idea of "social credit", where people who behave in ways

Fig.14: an image processed (right) with D-ID's software to protect the biometric data of the individual that is in the original image (left). Facial recognition systems cannot recognise the individual in the processed image, even though it looks almost the same to a human.

that are undesirable but not necessarily criminal can be punished in other ways, such as having restricted travel or being prevented from buying certain products.

Facial recognition and tracking is combined with all records pertaining to a person such as a criminal record (if any), medical records, travel bookings, online purchases, social media comments, friends on social media or elsewhere with the view of tracking where an individual is, who they are associating with, what they are up to, where they are heading, etc.

Apart from Xue Liang's use of physical records, it combines artificial intelligence, data mining and deep learning technologies to further enhance the system's effectiveness.

In addition to government surveillance cameras, the system also integrates private security cameras from places such as apartment blocks and shopping malls.

For more information, see this video from the Washington Post titled *"How China is building an all-seeing surveillance state"* at **siliconchip.com.au/link/aaoa**

Facial recognition at concerts

In April 2018, there was a concert of 60,000 people in China. A wanted person was identified among the vast crowd by facial recognition technology and arrested by authorities for "economic crimes". The suspect was apparently extremely surprised that he could be identified and pulled out of a crowd of so many people.

Letting a neural network decide what features are important in a face

A YouTube user by the name of "CodeParade" took 1700 faces and used a neural network program of his own design to encode information from those faces. Without human decision making, the program automatically decided what facial features were most important and assigned them a level of importance.

A number of adjustable slider bars were generated which were ranked by the program in order of importance, and these could be adjusted to discover what facial features they corresponded to.

It was not always obvious what facial feature(s) the neural network had selected. When the sliders were adjusted, the faces sometimes changed in unusual ways and the changes were dependent upon the position of the other sliders. See the video titled *"Video Computer Generates Human Faces"* at **siliconchip.com.au/link/aaoc**

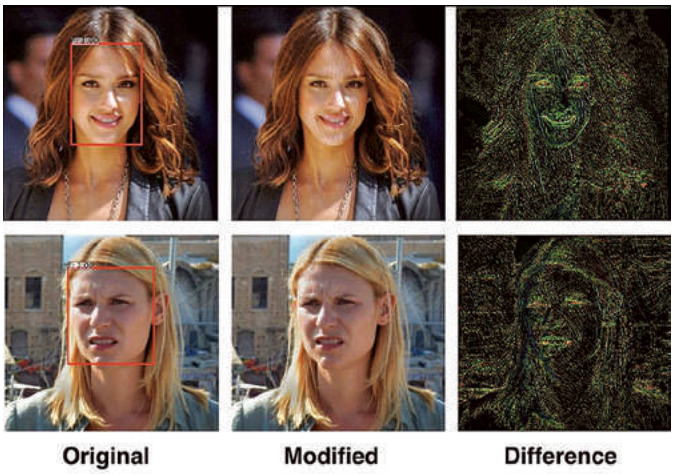


Fig.15: PrivacyFilter is another system to modify images, preventing them from being used for face recognition. It was developed by Joey Bose, an engineering student at the University of Toronto. This system has now been developed into a commercial product, "faceshield" (https://faceshield.ai/)

In May 2018, Taylor Swift used facial recognition at one of her concerts to identify any of hundreds of stalkers she claims to have. See the Rolling Stone article at: **http://siliconchip.com.au/link/aand**

Thwarting facial recognition

Many people who have nothing to hide still have concerns about being photographed or recorded without their knowledge. Their biometric data could be added to a database, which may cause problems for them in future, or their presence at certain locations could be logged to some central "Big Brother" database and used to track their movements.

One particular concern is the unauthorised use of their image in identity theft, or to gain access to restricted areas or devices such as smartphones protected with facial ID security.

As a result, Israeli company D-ID (**www.deidentification.co**) has developed a method to process pictures and videos to render them unidentifiable by facial recognition systems. Pictures to be protected might be staff pictures on company websites, for example. The images are subtly altered in a way which is barely or not discernible to a person but prohibits identification by a machine (Fig.14).

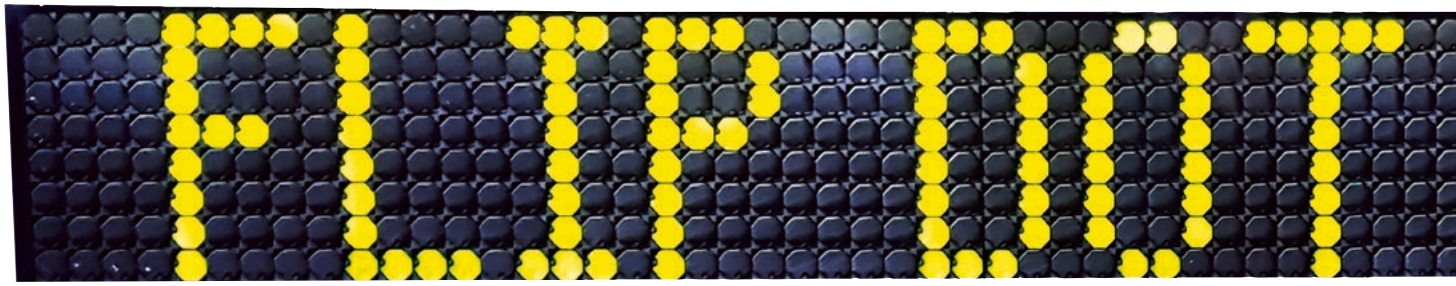
There are also legal ramifications of this because according to the European Union's General Data Protection Regulation (GDPR), currently in force, face images are regarded as "sensitive personal information" and organisations are required to protect this data or face penalties (no pun intended!).

Another approach to thwarting unwanted facial recognition involves the use of 3D printed eyeglass frames and this was the subject of an academic paper; see **siliconchip.com.au/link/aanc**

Unlike the 3D printed glasses that were the subject of this paper, regular glasses can be ignored by more advanced face recognition systems. The Japanese Government's National Institute of Informatics (NII) developed "privacy visors" in 2015 to thwart unwanted facial recognition.

Many other methods have been developed to thwart unwanted facial recognition such as unusual facial makeup or clothing with printed faces etc, but one would hardly go unnoticed! SC

BUILD YOUR OWN E-X-P-A-N-D-A-B-L-E



If you want a dot matrix display which has digits/letters over 90mm high, is visible under a wide range of lighting conditions and uses no power except when the display is changing, then our new and very cool FLIP-DOT display is for you. Seeing (and hearing) a flip dot display is quite something, so it makes a great conversation starter too!

You've probably seen the large yellow dot displays on the front of many Australian buses, trains, etc or perhaps in airports.

They're highly visible in bright sunlight or under cloudy skies, and they're usually illuminated at night too.

Contrary to what you might believe, they're generally not electronic signs as such: they're actually electromechanical flip-dot displays.

They're made from panels that are yellow on one side and black on the other. They rotate to change state, accompanied by a pleasing "clack-clack-clack" sound.

Well, now you can build your very own home flip-dot display! It's easy to build, uses just a handful of readily available parts and is controlled by an Arduino or MicroMite microcontroller.

So you can make it read just about anything you want. If you use a micro with a WiFI adaptor, you can even get it to download and display data from the internet, such as the temperature forecast or sports scores.

So-called flip-dot or flip-disc displays have been around for over 50 years and are still commonly used in countless applications.

Their simplicity and reliability have stood the test of time, and now, you can build your own.

For those not familiar with this type of display, each disc or flap which forms a pixel in the dot-matrix display also contains a small permanent magnet. An electromagnet can flip this magnet and thus the disc, to control which colour is visible from the outside. The polarity of the coil drive current determines which side of the disc appears. When power is removed, the display remains in its last state.

One complete unit – here displaying the letter "S" – sits upright of its own accord. We have fitted a small length of female header strip to CON1 and CON3 to allow connections to be made with jumper wires. See video: siliconchip.com.au/Videos/Flip-dot

These displays are designed for the discs to remain stationary until commanded to move. Our version has been simplified to make it as easy as possible to build, but it will still make a practical stationary display, and one which can be seen quite well in various lighting conditions and across a large room.

Many commercial flip-dot displays use numerous small coils wound onto tiny armatures – see the photo of one on page 24.

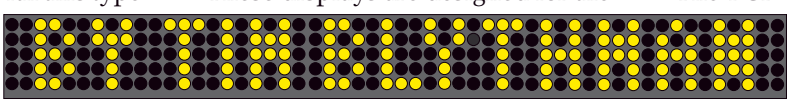
How our flip-dot display works

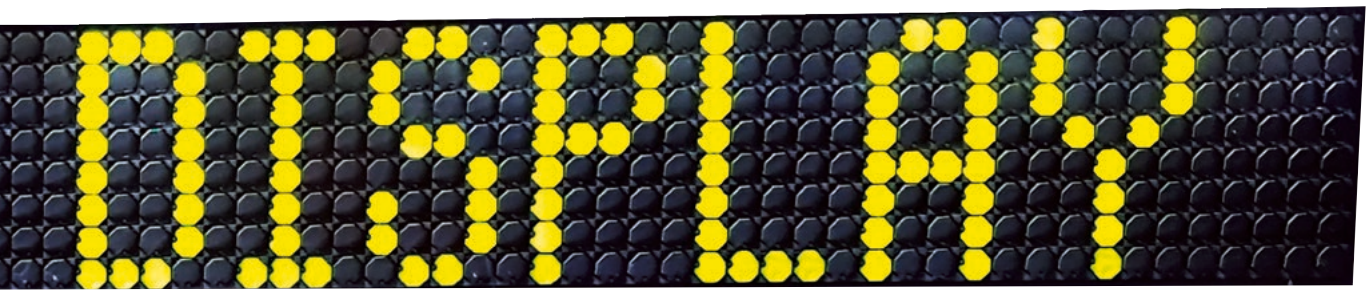
To simplify our display and make it substantially cheaper and easier to build, we have formed coils using PCB tracks instead. One PCB contains fifteen such coils on both layers – enough to produce a single character display by itself.

Each board consists of a matrix of fifteen pixels, arranged three wide by five high. This is just enough to display a capital letter, number or symbol. Each pixel consists of a piece of fibreglass that's black on one side and white on the other, with an embedded rare-earth magnet.

These sit over the PCB-track coils and are attached to that board in such a way that they can rotate through 180° on a pair of simple hinges, allowing either side of the black/white panel to be made visible.

The PCB underneath is also white on one side and black on the other, so that when the panel with the mag-





Features:

- **15-pixel display per board (three pixels wide, five pixels high)**
- **Each board can display a single letter, number or symbol**
- **Display boards can be daisy-chained for multi-character displays**
- **Customisable colours (BYO paint!)**
- **5V/3.3V 4-wire serial interface**
- **12V power supply required – 1.5A or higher (see text)**
- **Each pixel controlled individually**
- **Stackable for multi-row displays**

net flips, the whole area changes from black to white or vice versa.

All that the driver board needs to do to cause it to flip is to energise the coil underneath with the correct polarity.

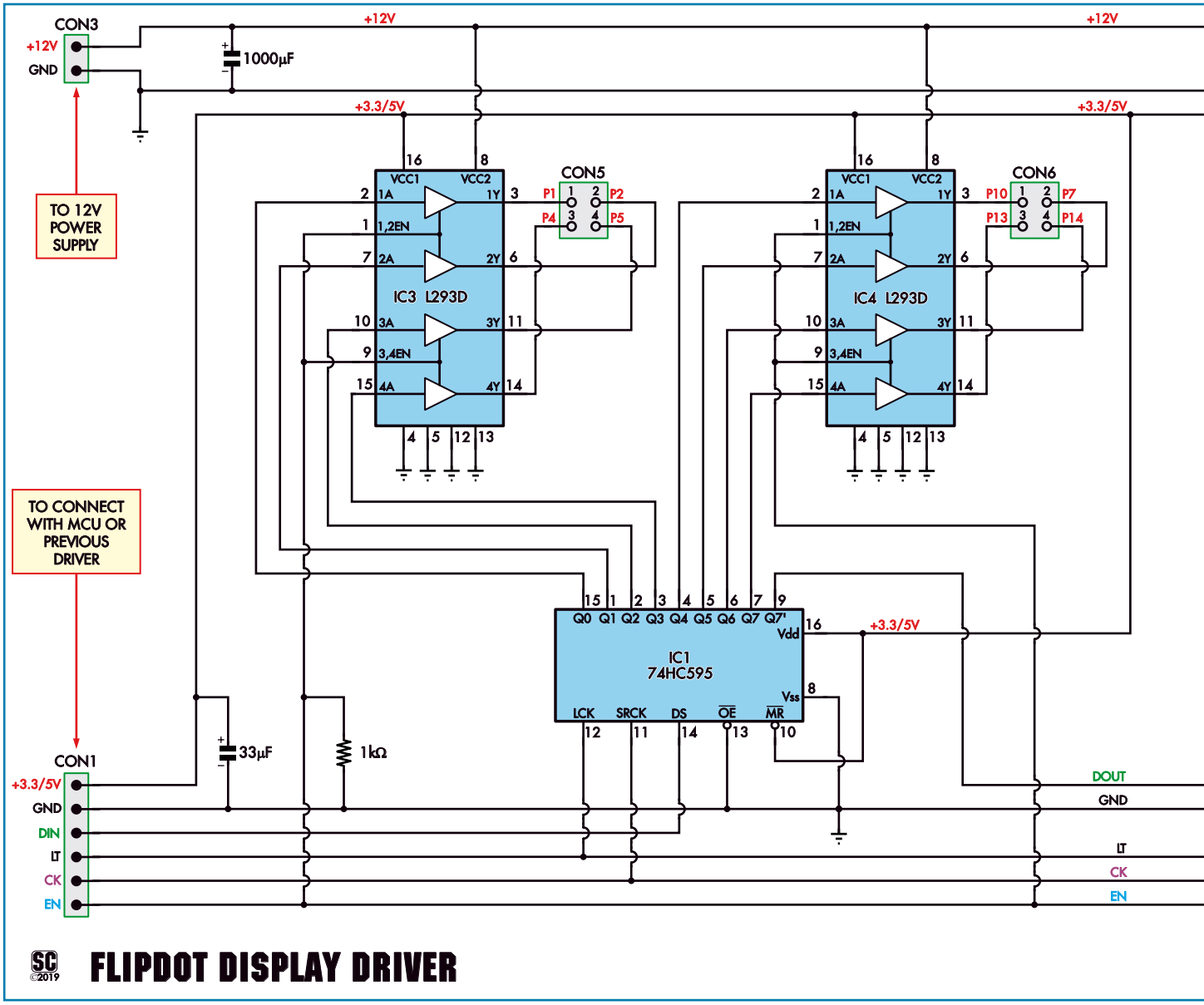
This will repel the magnet initially, causing the panel to swing through 90° until it is at right angles to the panel below. The magnet will then be attracted to the coil and continue moving due to inertia, until it is laying flat on the panel below but with the opposite orientation.

The pixel size (19mm wide and 17mm tall) is a compromise between the magnetic strength of the coil and the weight of the moving elements. Each coil has around 60 turns and measures just over 1.5m in track length, but is packed into an area less than four square centimetres. This is about the limit of what is possible with a two-layer board.

The magnets are 3mm x 1.5mm rare earth magnets glued into a hole on the flap PCB. It is important that the magnets all face the same way relative to the colours. This ensures that the flaps are interchangeable and consistently display the same colour.

The pixel flaps and the brackets holding the flaps to the panel are small PCBs too. A completed unit including the driver PCB will consist of 23 separate PCB pieces. The bracket PCBs are soldered to the main coil PCB, and the flaps are slotted in place, pivoting around their end tabs.

PCBs are a cheap, convenient way to achieve the correct mechanical dimensions required of multiple identical parts. By using PCBs with a black solder mask and white silkscreen printing, we can use the silkscreen layer to create pixels with very high contrast



FLIPDOT DISPLAY DRIVER

between the 'on' and 'off' states.

Due to the limited strength of the electromagnets, the display will only work reliably when standing upright, which it will comfortably do without any extra parts.

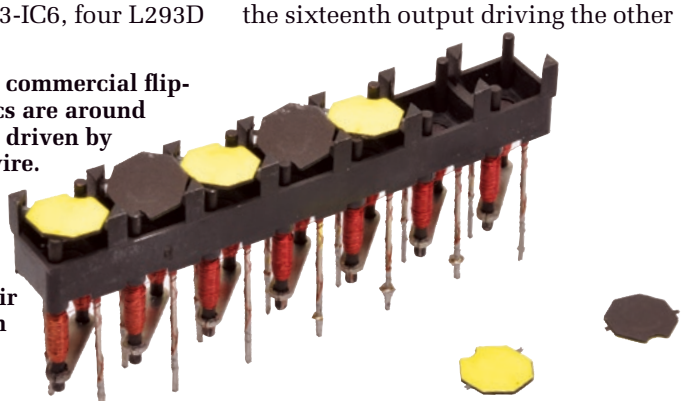
Driving the display

The display driver circuit is shown in Fig.1. It is designed to be controlled by a microcontroller using a simple serial bus, and is powered from a 12V DC supply. It connects to the coil circuit, shown in Fig.2, via headers CON5-CON8. This circuit represents one set of 3 x 5 pixels that can display a single character; characters can be daisy chained to form larger displays. We'll explain how that works shortly.

The driving signals from the microcontroller are fed in via six-pin header CON1. They pass to IC1 and IC2, two 74HC595 shift registers, which decode the serial data stream and use it to control the state of sixteen separate digital outputs (QA-QH on each IC). These control signals will normally be either 0V (low) or 3.3-5V (high).

These digital outputs connect to the control inputs of IC3-IC6, four L293D dual H-bridge motor drivers, which provide the current required to drive the fifteen coils, as well as converting the 0-3.3/5V control signal voltage swing into a higher 0-12V swing to drive the coils.

Fifteen of the motor driver outputs connect to one end of each coil, with the sixteenth output driving the other



The mechanism of a commercial flip-dot display. The discs are around 9mm across and are driven by coils of enamelled wire. The magnetism remaining after the current has ceased is enough to hold the discs in their last position, or even snap them back if they are moved.

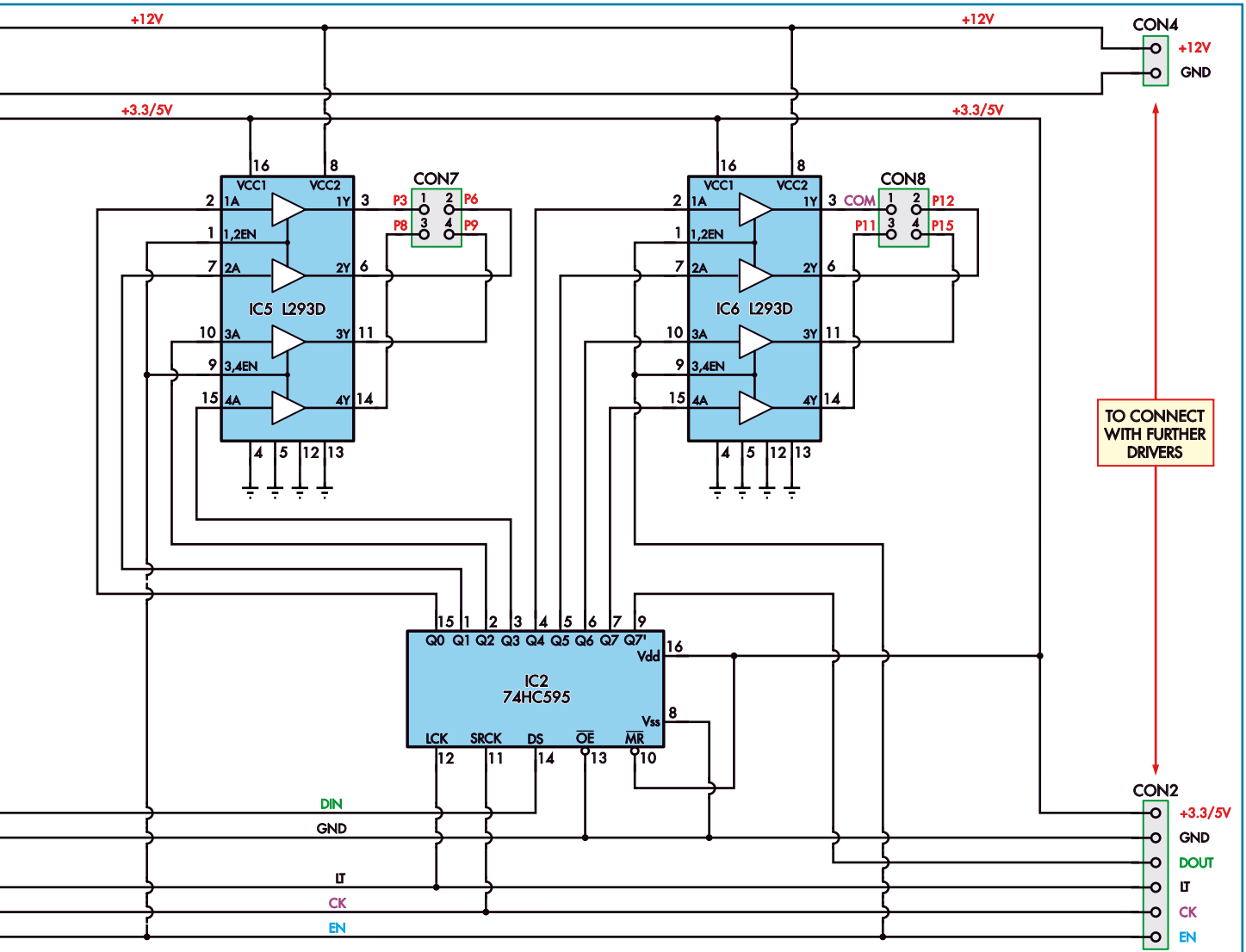


Fig.1: the circuit of the driver for one 3 x 5 pixel Flip-dot display. The control signals and logic supply from CON1 are fed to IC1 & IC2, two 8-bit serial-to-parallel latch ICs. These drive the 16 control inputs of L293D dual H-bridge motor drivers IC3-IC6. Here, they are driving 15 coils etched in a separate PCB, shown in Fig.2.

end of all the coils, which are joined together (common or COM).

So to flip a single pixel, the common (COM) output goes either low or high, and one of the other fifteen outputs (P1-P15) is driven with the opposite polarity. This causes current to flow through that one coil in a direction determined by the output polarities.

The direction of current flow determines whether the coil produces a North or South magnetic pole in proximity to the permanent magnet.

The software needs to ensure that only one coil is driven at a time, because all the coil currents return to the same common driver pin. While this pin may be capable of sourcing/sinking enough current to flip more than one pixel at a time, we've found it to be a bit marginal, and it results in IC6 (which drives the COM pin) getting rather hot. So our software flips one pixel at a time.

To achieve this, all outputs are set high or low, except for one, which is set to the opposite polarity. Any output that is set the same polarity as the COM pin will cause no current to flow through the connected coil. Only the single coil that is driven with a different polarity will receive current.

The instantaneous current requirement of the coils is around 1A with a 12V supply, which is above the continuous rating of the L293D. But the coils only need to be pulsed briefly, so the average current is much less than the peak current. The microcontroller pauses briefly between updating each pixel, to keep the average current under the thermal limit and to allow the pixel time to finish its flip manoeuver.

Since the display holds its state with no power applied, the circuit's average operating current is not usually terribly high. Note that no more than two of the four drivers on any IC should be active at a time.

The enable pins of the four L293Ds (pin 1 of IC3-IC6) are joined together and held low by a 1kΩ pull-down resistor, so that the default state of all the outputs is off (high-impedance). It isn't until the microcontroller pulls the enable lines high, via pin 6 of CON1, that IC3-IC6 are activated and that is only done once the control data has been shifted through IC1-IC2 and latched at their outputs.

The enable pins are only pulled high for 100ms at a time, to limit the current pulse duration, as explained

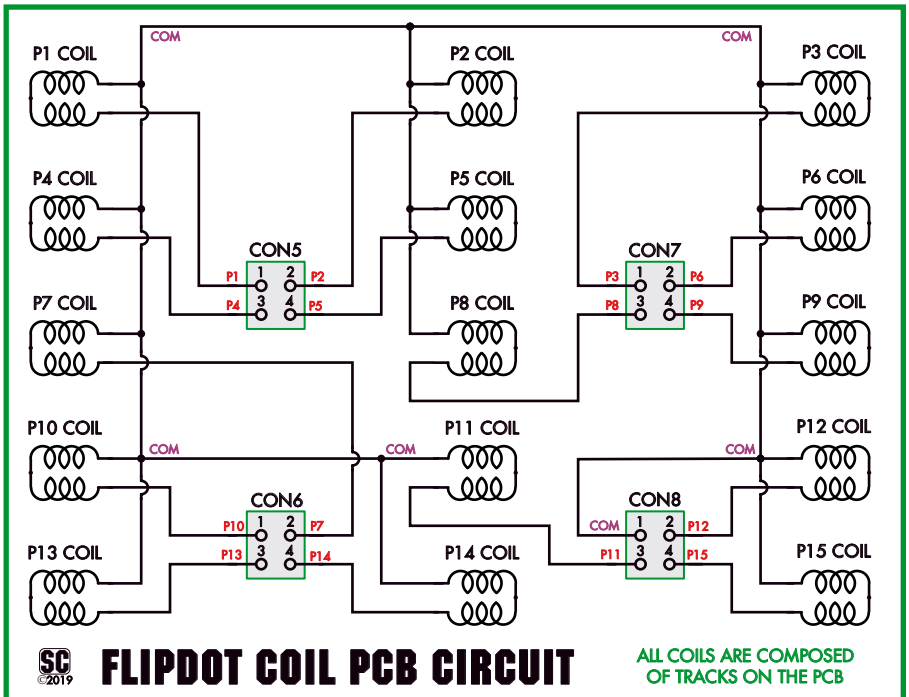


Fig.2: the fifteen coils on this PCB are driven by the circuit of Fig.1 and either attract or repel permanent rare-earth magnets mounted in pixel flaps on top of them. Because those rare-earth magnets have a North pole on one side and a South pole on the other side, depending on the direction of current flow through a coil, the flap flips to one side or the other, exposing a different colour.

above. Due to this relatively long drive time, the extra time taken to shift control data from the micro through IC1-IC2 is negligible.

As required by the L293D, the logic ground and power ground are common. Separate connections for 12V power and 3.3V/5V logic supply are available, via CON3 and CON1 respectively.

Construction

Being a mechanical design with moving parts, a fair degree of precision in the construction is required to ensure proper operation. The primary requirement is that all the parts are put together squarely and lined up correctly before fixing them in place.

The first step is to glue the magnets in the pixel flaps. We highly recommend that the flaps be left in the PCB frame during this step, to avoid pieces getting lost. The flaps are spread out enough that interaction between the magnets is minimal.

We do this step first to allow time for the glue to cure. We used epoxy resin as it has a bit of resilience and is quite strong; cyanoacrylate-type glue (superglue) is probably too brittle and might causing the magnets to come loose after some use.

To make this process easier, you need a disposable, flat plastic surface. The lid from an ice-cream tub or takeaway container is ideal, as epoxy will not stick to this. Another helpful item is a flat sheet of ferrous material (something that a magnet would stick to, such as plain steel). This can be used to help hold the magnets in place. We used a steel case, but you could also use the lid of a Milo tin.

Place the ice-cream tub or takeaway lid over the ferrous material, then sit the PCB frame on this. Once you insert the magnets in their holes, they should be held in place by their attraction to the steel, but the ice cream lid will allow them to be removed without too much force. The most critical point of this step is that all the magnets' poles line up.

To achieve this, take the stack of magnets (they'll form into a stack of their own accord), and push the magnet at the end of the stack into one of the holes in the pixels. Then detach it from the stack by sliding the stack to the side, leaving a single magnet sitting in the hole. The PCBs are 1.6mm thick, so the magnets should sit just below the surface of the PCB.

You will see that there are 16 pixel flaps in the frame, but we only need 15, so there is a spare if needed.

Then repeat for the other 14 or 15 pixels, without changing the orientation of the stack. When you've finished, you may want to check the magnetic polarity by moving another magnet nearby (but not so close that it pulls them out). You should feel that all the magnets are attracted to the magnet in your hand without changing its orientation.

Mix up a small amount of epoxy resin, and apply a film to the top of each magnet in its hole. Try to work it down the sides if possible. The rough edges of the PCB will provide good purchase on the glue. Finally, wipe down any excess. Any extra glue may foul and unbalance the mechanism.

You should also ensure that the PCB panel is still flush with the plastic below, as if it is sitting up, the magnets may end up protruding slightly.

Allow the resin to harden. We rec-

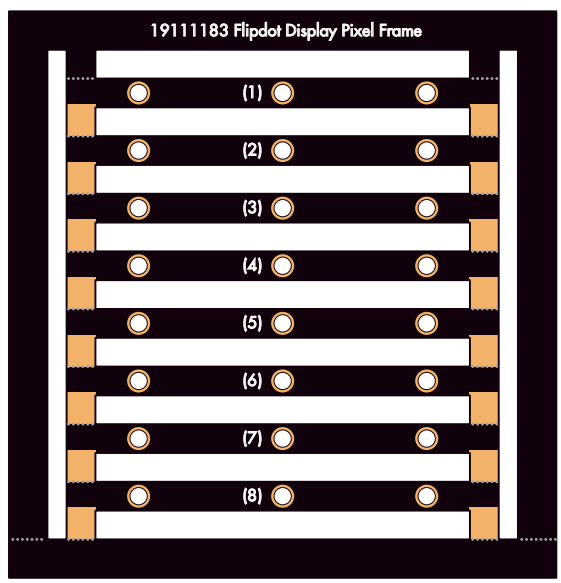


Fig.3: this PCB can be cut apart into eight separate frame pieces - enough to make one 3 x 5 pixel flipdot display with two pieces left over. The holes form the 'hinges' for the pixel flaps to rotate about, while the exposed copper is soldered to the coil PCB to hold the frame in place. Cut carefully where shown using a side-cutter to separate the pieces. The frame pieces are quite thin and could be damaged if handled roughly.

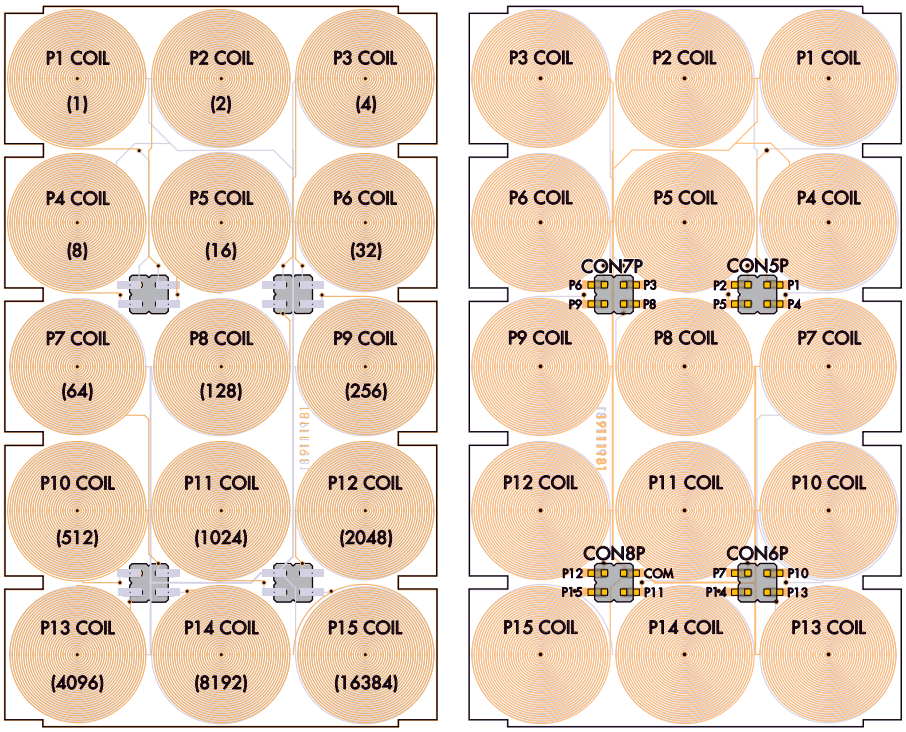


Fig.4: the coil board. Each coil is made from copper on both sides of the board. Solder four 2x2-pin SMD headers to the back side of this board, as shown. The only parts soldered to the top side of the board are the six frame strips which hold the pixel flaps in place. Add numbers in parentheses for each pixel that you want to be 'on' to determine the code used to produce a particular character. For example, 2+8+32 = 42 will give you a caret (^) on the display.

ommend that you leave it longer than suggested by the manufacturer to ensure it is fully cured. If it is still sticky, it may gum up the mechanism and make handling difficult.

If you wish to change the colour of the flaps, after the resin has cured is an ideal time. A thin coat of paint should be used to ensure that the flaps do not become too heavy. You could use spray paint, one colour on one side, and a second colour on the other side.

You could apply the same colours to the coil PCB, although this will need masking to ensure the colours are kept separate.

However, we think most constructors will be happy with the black and white as supplied, since it provides good contrast under just about any lighting conditions.

Note that if you are building multiple displays to be ganged together, it's a good idea to ensure that the magnetic polarity is consistent across all the displays, to avoid extra software complexity.

If different characters have different pixel black/white orientation, this will need to be programmed into the software, so that it can give a consistent display across characters.

Building the frame

You will need six frame elements to build one fifteen-pixel display. But note that if you are going to be stacking two frames vertically, you will only need eleven in total; one frame will be shared between two boards. The frame pieces are cut from a 72.5 x 75mm PCB which contains eight separate frame

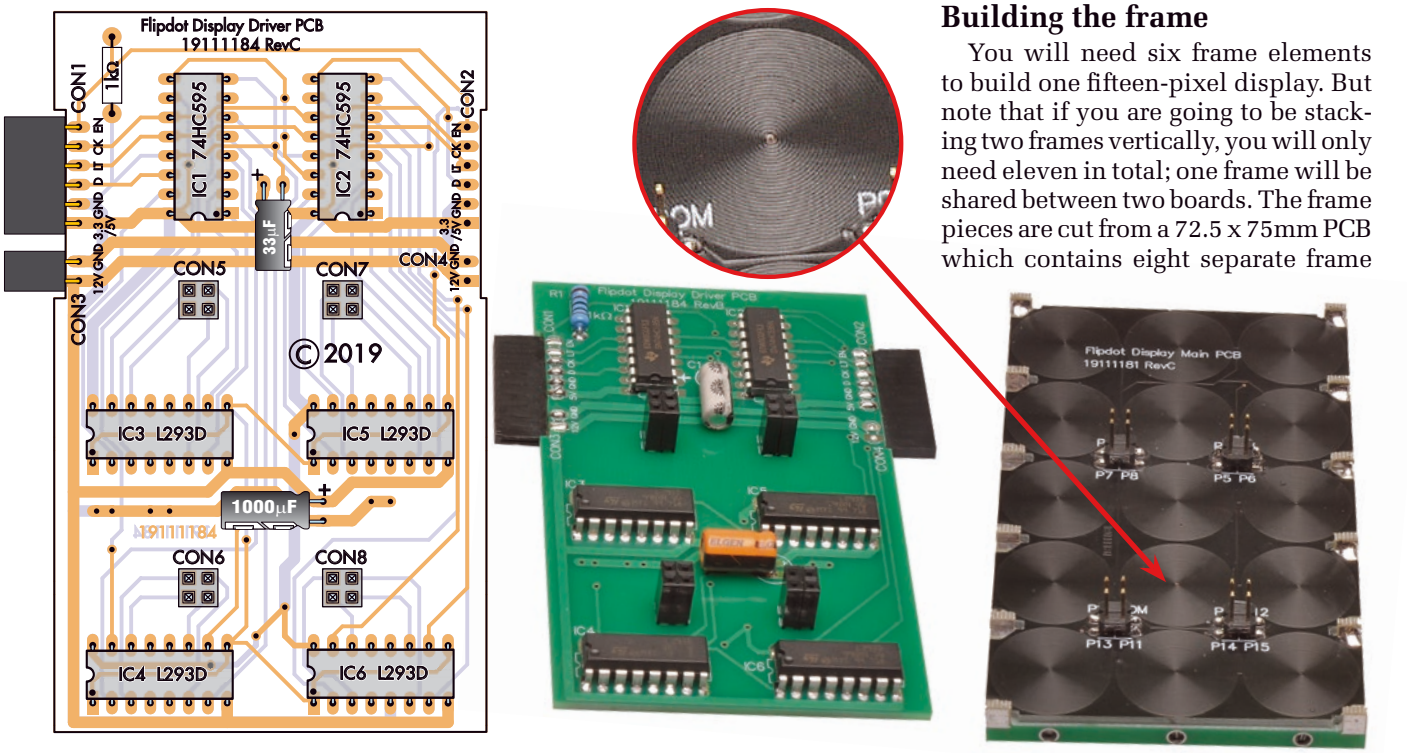


Fig.5: use this PCB overlay diagram and the photo above as a guide to assembling the driver board. Note the location of the headers for CON1 - CON4 and the orientation of the ICs. The two capacitors will need to be laid over to sit under the coil PCB. The female headers are convenient for using jumper wires to a Micromite or Arduino, although you may substitute anything that suits. At right is the Flipdot display main PCB – it may not be immediately obvious that the circles on this board are in fact coils (see inset) which are responsible for "flipping" the "pixel" either white or black.

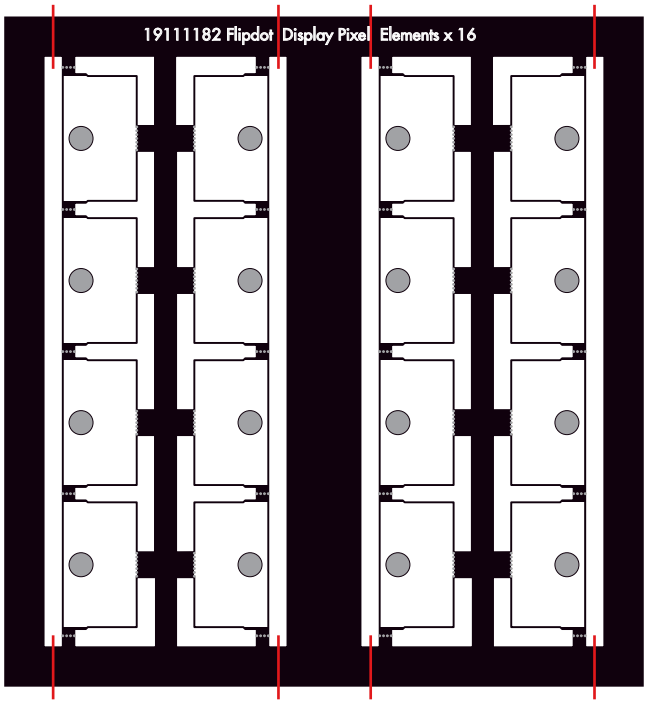


Fig.6: as with the frame pieces, the sixteen pixel flaps are made from PCB material and come joined together. Cut along the red lines using a sharp pair of side cutters, then separate them at the 'mouse bites'. You can use a file to gently clean up the rough edges if necessary. The magnets are glued into the grey-shaded holes in the middle of each pixel.

pieces, as shown in Fig.3.

Carefully break the frame pieces out of the PCB panel. You may find it easier to cut one side out of the panel with side-cutters before separating each element along the perforated mouse-bites.

The frame pieces do not need to be cleaned up to work correctly, although they can be filed flat along the mouse-bite edges if you prefer. The PCBs are made of fibreglass, so any filing should be done outside with a mask, to avoid breathing in fibres.

The long, flat edge is visible from the front of the display when mounted, so you may wish to colour this black (eg with a marker or paint) to improve the contrast of the display. Note that while our photos show green frames on our prototype, the final boards (available from the Silicon Chip Online Shop) will have a black solder mask instead.

The frames sit on the front of the coil PCB but are soldered at the back, so you won't see any solder when looking at the display later. Line up the edges of the two PCBs; the frame should sit at right-angles to the coil PCB. You will need a fairly large soldering iron tip and be generous with the solder to ensure the fillet bridges the gap.

It's a good idea to solder one of the tabs at the back and check the position before soldering a tab at the other end.

You might like to leave just one tab soldered until the flaps are fitted, as this will give a small amount of flex to the frame, allowing the flaps to be slotted in with less effort.

If you do this, though, make sure to come back later and solder at least one more tab on each frame piece, once you have confirmed that the unit works correctly.

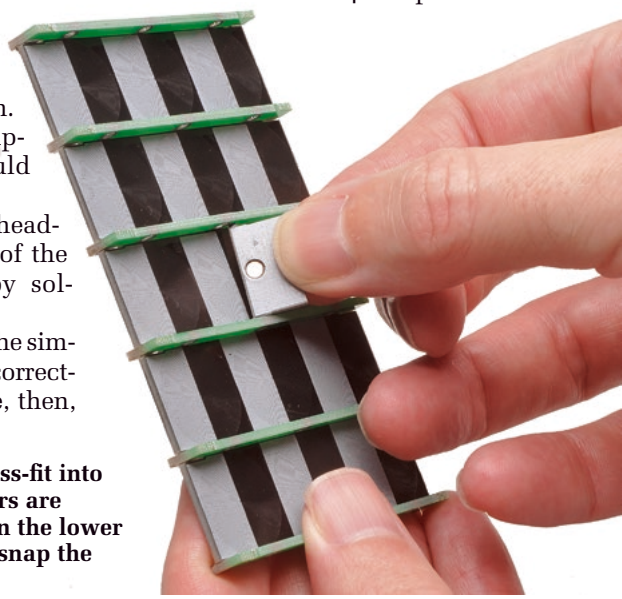
The coil PCB is probably the most delicate part, as the fine copper traces are near the limit of manufacturing tolerances. The traces run quite close to the edge of the board, and if they are damaged, they will be next to impossible to repair and the display may not work correctly. So be careful with it.

On the reverse of the coil PCB, there are pads for four 2x2 pin SMD male headers - see Fig.4. These headers are a similar size overall to their through-hole equivalent.

It's a good idea to push the female header sockets (which will be soldered to the driver board later) over the pins on the SMD headers before soldering them. This way, if too accidentally apply too much heat, they should stay in alignment.

The use of surface mount headers here means that the front of the display remains unspoiled by soldered joins.

As with any other SMD part, the simplest way to locate the headers correctly is to solder one pin in place, then, after checking that it is in the correct location, solder the remainder. The mating holes for the female headers on the driver PCB are slightly oversize, to allow for minor inaccuracies in the placement of the male headers.



The pixel flaps are a simple press-fit into the holes. Ensure that the colours are aligned as shown, slot one tab in the lower hole and then rotate the flap to snap the other tab into the upper hole.

Driver PCB construction

The driver PCB can be built next. We recommend fitting the ICs first, as their placement is not critical. Refer to Fig.5, the PCB overlay diagram, to see which parts go where.

IC1 and IC2 are both 74HC595s and these are fitted at the top of the PCB, with their pin 1 facing down. IC3-IC6 are L293D types, and these go at the bottom of the PCB, with their pin 1 to the left. All six ICs have 16 pins, so take care that they do not get mixed up.

We recommend soldering them all directly to the board, rather than using sockets, for reliability (and because the pins of IC3-IC6 carry fairly high currents). You could use sockets for IC1 & IC2 if you really want to.

After confirming that the ICs are well seated and correctly orientated, solder all the pins to the PCB, ensuring that you do not put too much heat into the IC. The ground pins on IC3-IC6 (the four pins closest to the centre) sit on a large copper area to provide some heatsinking, so these pins may require extra heat to ensure a good solder joint.

Next, mount the capacitors. Both are the polarised electrolytic type, so observe the polarity marks on the PCB. The longer leads go into the pads marked with a "+" sign, while the striped side of the can is negative. The smaller 10µF capacitor sits

between IC1 and IC2. You will need to lay it over on its side, as the coil PCB will sit quite close above it.

The 100µF capacitor fits between IC5 and IC6. It too will need to be laid over. It does not matter which way the capacitors are laid as there is ample space on the PCB.

Fit the female headers next. A good way to ensure that they are mounted square and parallel is to push them over the male header pins on the coil PCB, and use this as a jig to line them up with the holes in the driver PCB.

Note that if you fitted the female headers to the back of the driver board (which we don't recommend) then you could still plug the two boards together. But you would need to modify the software to make it work, since the connections on CON5-CON8 would all be reversed. Our code assumes that these headers are on the same side as the other components, so the driver ICs are sandwiched between the two boards.

Ensure that the two boards sit parallel before soldering the female header pins. The holes are slightly oversize, so these pins may need more solder that you might expect.

An alternative to using the female headers is to simply solder the male headers of the coil PCB directly into the driver PCB. You may prefer this if you are building a larger display made of smaller modules, although it will obviously be harder to repair any faults.

Finally, you will need a way to connect the driver PCB's input pins to a microcontroller and power. There are two headers for this. CON3 has two connections for 12V and ground, while CON1 has six connections for 3.3/5V power, ground and logic-level control signals.

CON1 and CON3 are spaced 0.1"

Parts list (per each 3 x 5 pixel display)

1 black double-sided PCB coded 19111181, 96x58mm (coil board)
1 green double-sided PCB coded 19111184, 96x58mm (driver board)
6 pieces from black PCB coded 19111183, each piece 58x8mm (frame pieces)
15 pieces from black PCB coded 19111182, each piece 19x10mm (pixels)
15 3mm diameter, 1.5mm thick rare earth magnets
4 2x2-way SMD male header [eg, snapped from Altronics P5415]
8 2-way or 4 2x2-way female header sockets
1 9-pin female or male header (CON1,CON3) (see text for details)
Epoxy Resin for gluing magnets into flaps

Semiconductors
2 74HC595 8-bit shift registers, DIP-16 [Altronics Z8924, Jaycar ZC4895]
4 L293D motor driver ICs, DIP-16 [Altronics Z2900, Jaycar ZK8880]

Capacitors & resistors
1 1000µF 16V electrolytic capacitor
1 33µF 6.3V electrolytic capacitor
1 1kΩ 1/4W 1% metal film resistor

Additional parts
1 12V DC 1.5A power supply (*higher current may be needed for multi-character displays*)
1 Arduino or Micromite board for control
1 set of jumper leads to connect to microcontroller and power supply

Note: the four PCBs are available as a set at a discounted price (SC4950)

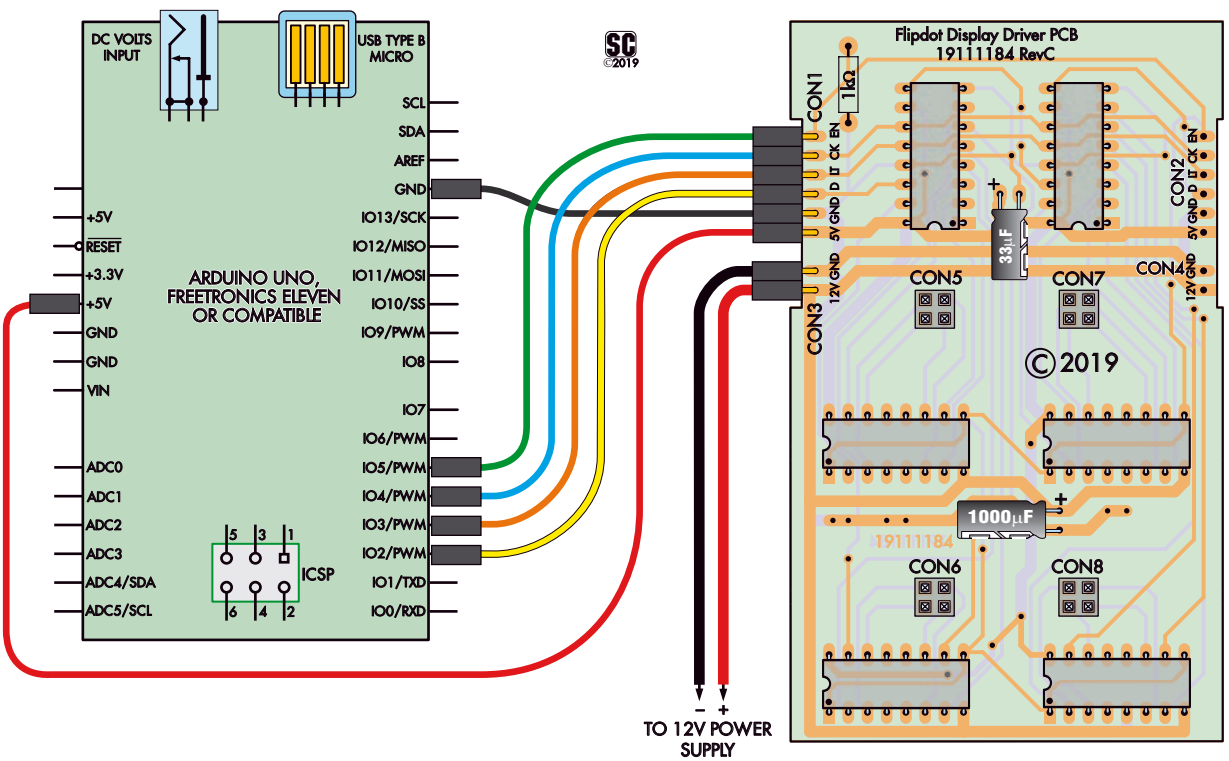


Fig.7: this wiring diagram shows how the Flip-dot Display can be connected to just about any Arduino-compatible board. The microcontroller needs just four digital outputs to control the display.

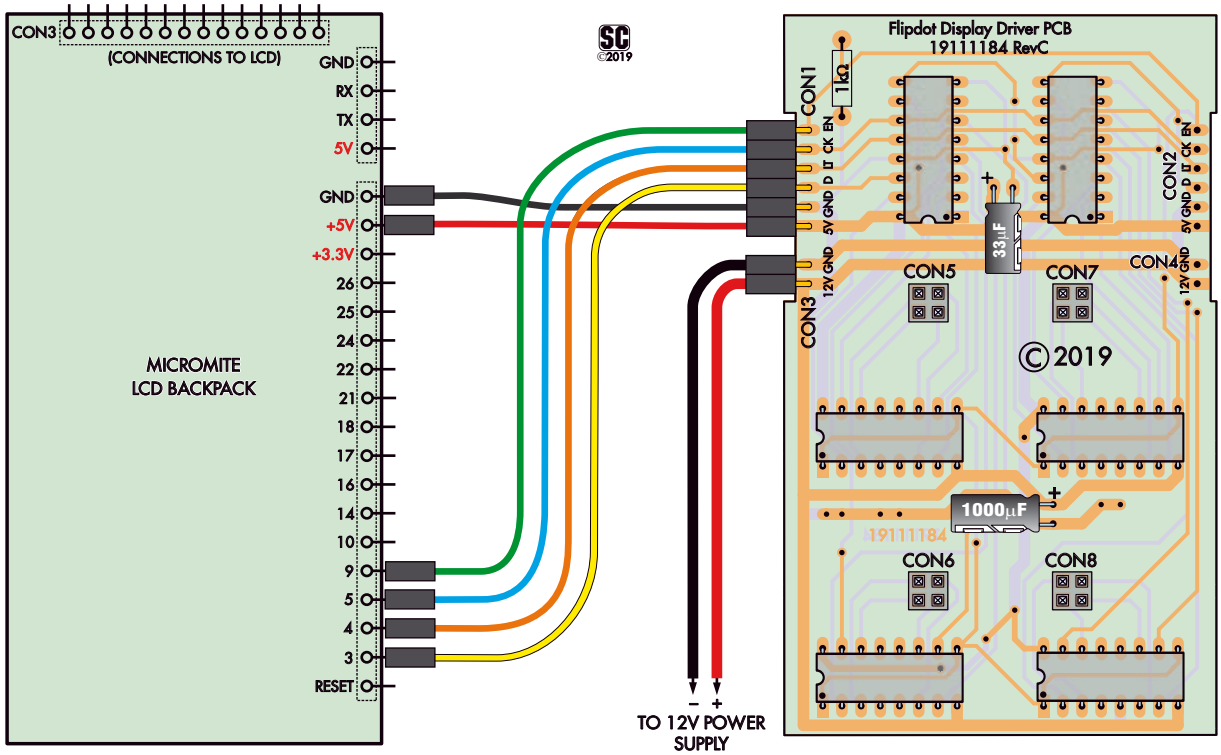


Fig.8: a microcontroller with 3.3V I/O can also control the Flip-dot Display directly, such as the Micromite shown here. This is the recommended wiring, which allows you to use our test and sample programs without having to modify them.

(2.54mm) apart, so a nine-pin header can be fitted for both, and that is what we've done. It can be broken or cut off a longer header strip if necessary. Solder this to the holes on the left-hand side of the PCB.

For the first board, which will be wired back to the controlling device (Arduino, Micromite etc) it's best to use female header(s) for CON1 and CON3, to allow male-to-male jumper wires to be used.

But for subsequent boards in a multi-character display, you're better off using a male pin header for CON1 and CON3 instead. This can then be soldered directly to the CON2/CON4 positions on the adjacent board, which holds the two together and allows the PCBs to butt right up to each other, thanks to the two shallow cut-outs on the edges of the board, into which the header's plastic block slots.

Another option would be to fit a female header (socket) for CON2/CON4 on one board, and a male pin header for CON1/CON3 on the next board, and plug them together. This would make it easier to disconnect the boards later if necessary, but they would then have a gap between them. And you would need to come up with a way to hold them together, since the socket won't provide enough friction.

CON2 and CON4 are not needed for a single display. You can leave them off at this point, and fit something later after you have tested the unit, if you decide to combine it with additional display boards.

Final assembly

Now that the glue and paint on the pixel flaps has cured, these can be fitted to the coil PCB's frames. But first, they need to be removed from the PCB panel.

The best way to do this is to carefully cut the panel into smaller pieces using a sharp pair of side-cutters. Take care that the PCB material is quite brittle, and the cut pieces may tend to fly off. Aim away from the body, and use eye protection. Fig.6 shows the recommended cutting locations.

Now, without using any tools, break the flaps by hand from the panel along the mouse-bites. We found that the rough edges were generally not a problem, but they can be filed back a small amount (one or two passes only) with a fine file. Again, beware of breathing the dust from the PCB.

A good test to check that the pixels are all magnetically aligned correctly is to allow them to attract each other into a single stack. If all the flaps show the same colours on the same side, then they are aligned magnetically.

The pixel flaps are simply a firm press fit into the frames. Line up the colours so that the white side of the flap is adjacent to the white side of the coil PCB and the black side of the flap is adjacent to the black side of the coil PCB (see photo).

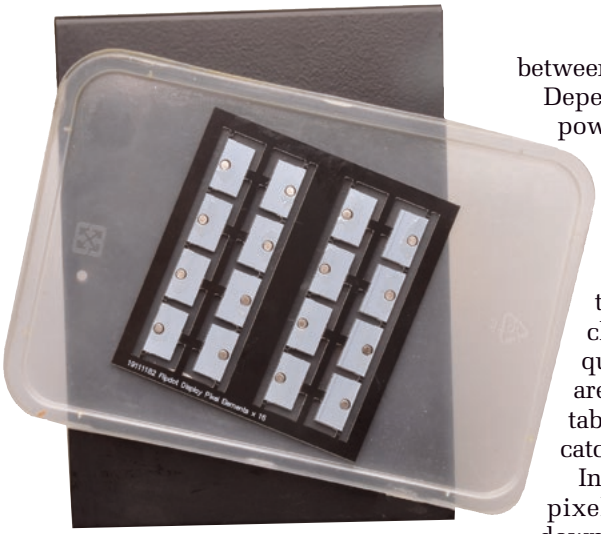
Sit the bottom tab into the hole in the frame, and then gently rotate the upper tab into the hole. Once all the flaps are installed, check that the pixels will all flip freely. This can be done by rotating the entire assembly in your hand and allowing the flaps to move under the influence of gravity.

Connect the coil PCB to the driver PCB by plugging the headers together. The assembly should sit upright on its bottom edge, with a very slight backwards tilt. The backwards tilt will help the flaps to stay in their last driven position.

Connect the micro

The final step for testing is to connect a microcontroller to control the pins. You will also need a source of 12V DC, with preferably at least 1.5A capacity. The ground and 12V supply are connected to CON3, while the 3.3V/5V power and logic signals go to CON1.

See the diagrams for either the Arduino (Fig.7) or MicroMite (Fig.8) to



A small amount of epoxy resin is all that is needed to hold the magnets in the flaps. The steel panel (underneath) keeps the magnets flush, and the plastic inbetween stops the magnets sticking to the steel.

suit what you are using. If you are using a microcontroller which has been previously programmed for other purposes, we suggest that you re-program it with the software for this project before wiring it up, since if it drives the enable pin high without resetting the latch ICs first, that could cause the driver ICs to overheat.

Testing

Our first test program for either the Arduino or Micromite just cycles between all pixels white and all pixels black. Load this into your micro board (at this point, we're assuming you're comfortable working with Arduino or Micromite modules).

Both programs define which micro output pins control the flip-dot display via constants at the top of the program code. The pin configuration can be changed by changing the #define or CONST values. The default pins are grouped together, in order, for simplicity of wiring.

Check that the board works as expected and that the driver ICs and the coils don't get hot. They may get warm, but if any are too hot to touch, something is not right. If this case, there may be a wiring problem or the driver PCB may be assembled wrong. For example, swapping the clock (CK) and latch (LT) lines between the micro and driver board will cause problems.

If you see multiple pixels flipping at the same time, that is also a sign that the wrong data is being received from the board, pointing to a wiring error between the micro and the driver PCB.

Depending on the rating of your power supply, a fault may cause the L293Ds or the coil PCB to get very hot. Take care when touching the display if you suspect a fault.

Once you have confirmed that it's working correctly, check that the pixels flip in sequence. If you find one or two are not turning over correctly, the tabs at the end of the flaps may be catching against the adjacent pixel.

In that case, remove any sticky pixels by gently pushing them down against the frame and tilting them out of the mounting holes. File the ends with just one or two passes of a file, again being wary of the PCB dust.

Double-check that the other pixels are seated correctly in their mounting holes and that they can rotate freely. Then refit the ones you filed, ensuring that the colours line up correctly. You may find that they will operate more smoothly after bedding in (ie, running the test program for a while). Once you are happy with the operation and wiring, try the other example programs.

The Flip-dot ASCII 2 example sketch also contains a routine that only changes pixels that need to be changed, improving the update speed and reducing the power requirement.

Using the display

Both the Micromite and Arduino programs make use of a 16-bit value to store the displayed data for a single board. Fig.4 shows the bit mask values of each pixel. To create a particular configuration, add up the values for each pixel that you want to be black and ignore those which you want to be white. The resulting number represents that configuration and can then be used in the software.

If you find the colours are reversed to what you expect, then there are constants defined at the start of the program which can be changed to reverse the colours. Check the comments in the files to see.

This can be caused by all the magnets being reversed relative to what the program expects. So it's entirely possible that you will have to change these constants.

Multi-character displays

As mentioned earlier, multiple displays can be chained together to make a larger display by fitting a male header for CON1/CON3 on the second and subsequent boards and soldering these to the CON2/CON4 positions on the adjacent board.

This results in all the control and power pins being connected in parallel, except for the data pin.

The data out signal (pin 3 of CON2) connects to the data in signal (pin 3 of CON1) on the subsequent board, so that serial data passes from one board to the next and therefore, the controlling micro can independently set the state of all pixels in the chain.

Note that the enable pull-down resistors of connected boards are effectively connected in parallel, so you only need to fit this resistor to the first board (ie, the one that will be connected to the micro).

The coil PCBs can also be joined by soldering the tabs of the frame PCBs on adjacent boards. This can also be done to connect multiple rows of boards vertically.

While a single Flip-dot display is modestly sized by itself, with four or six units placed side by side, you could create an attention-demanding clock which gives you a gentle audible alert every time the minutes or seconds digit changes.

With multiple displays, each panel is capable of updating one pixel at a time, so the update time does not increase as you add more characters, as long as your power supply is capable of supplying enough current for all the displays to be driven simultaneously.

12V supply

You may need a 12V supply capable of several amps for a multi-character display, and we recommend that you parallel the 12V bus with wires that have a decent current-carrying capability, to help deliver that extra current to all the boards.

The software uses the shift registers to shift in the new data for each panel, then toggles the global enable line and they all update in sync.

The largest and most complicated sample program provided allows you to define the number of characters in your display, then update them all with a new text string as required.

Note that lower case letters in this string are automatically mapped to upper case, since those are much clearer when displayed on a 3 x 5 pixel matrix. Numbers and symbols are left as-is. SC

Field programmable gate arrays (FPGAs) are extremely powerful but until recently, programming them has been an arcane* art. Now, thankfully, it has been made much simpler and easier due to the availability of beginner-friendly development boards and free, open source graphical programming software. We explore what you can do with the low-cost and compact iCEstick board, and free IceStudio software.

Tim Blythman introduces the

iCEstick

An easy way to program FPGAs

** arcane: a "black art", details of which are known only to very few*

For a long time, FPGA programming and development has been difficult, especially for the hobbyist who doesn't have access to the often expensive tools that are needed.

On top of this, understanding the language that is used to describe a design can be a challenge, as is getting one's head around the ways FPGAs work differently to microcontrollers.

The iCEstick development board from Lattice Semiconductor (a major FPGA IC manufacturer) is a compact unit which plugs into a USB port.

Thus the board and programming hardware are one and the same, requiring only the extra components for a particular application to be added on.

Even this is not always necessary, as the board sports five LEDs which can be controlled by I/O pins, plus an on-board infrared transceiver.

The code for the iCEstick can be generated using Lattice iCEcube development software, available with a free licence. The Diamond programmer software is then used to program the iCEstick with the resulting file.

We also tried an open-source alternative called IceStudio. It has a graphical interface, allowing logic blocks to be dragged and dropped, then connected by virtual wires to create a representation of the circuit to be synthesised. It is a complete IDE, allowing design, building and uploading to occur.

For users who are comfortable with how logic gates and other basic elements like flip-flops work, this is an ideal way to bridge the gap of understanding between having an idea in one's mind and turning it into a functioning circuit.

IceStudio also allows 'code blocks' containing Verilog code to be created, so those who are familiar with Verilog are not limited by the included graphical symbols.

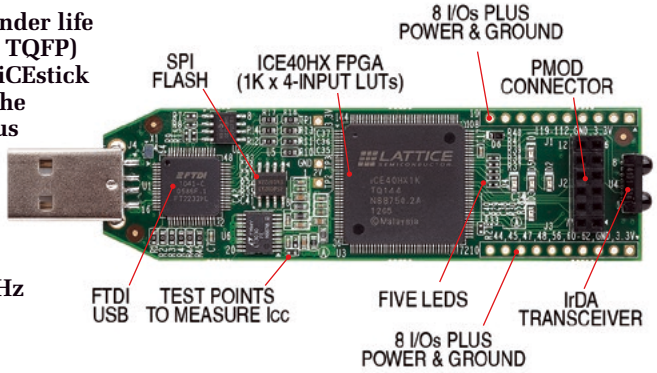
Verilog is a bit like the C language, as used to program Arduinos, but is designed to produce logic block structures rather than machine code.

What is an FPGA?

While we briefly touched on FPGAs in our recent review of the Arduino MKR Vidor 4000 (March 2019; siliconchip.com.au/Article/11448), here is a brief overview.

As mentioned above, FPGA stands for "field programmable gate array", and this means that it consists of logic gates, flip-flops and other 'glue' logic which can be reconfigured to perform different functions.

While this is an over-simplification, you can think of an FPGA as an IC containing thousands of 4000B/74HC/74LS chips connected via crossbars, in effect allowing you to change how the inputs and outputs of those devices are connected, to form virtually any function. And since they are all inside the same chip, very high speeds are possible; up to 500-1000MHz in some parts.



The iCEstick, slightly under life size. The huge (144-pin TQFP) IC in the middle of the iCEstick is the iCE40HX-1k. To the right of it are the various I/O headers and five user LEDs. To the left are the flash and EEPROM ICs, an FTDI 2232H dual UART and a 12MHz oscillator.

Pin No.	Function	Pin No.	Function
21	12MHz Osc.	90	PMOD 9
8	UART TX	91	PMOD 10
9	UART RX	95	LED5 (GREEN)
78	PMOD 1	96	LED4 (RED)
79	PMOD 2	97	LED3 (RED)
80	PMOD 3	98	LED2 (RED)
81	PMOD 4	99	LED1 (RED)
87	PMOD 7	105	IR TX
88	PMOD 8	106	IR RX

Table1: iCEstick physical pin to I/O pin mapping

The advantage that this arrangement has over a microcontroller is that everything happens at the same time in an FPGA.

Rather than having to wait for things to process in a sequence, determined by the list of instructions which form the program, everything happens practically instantly in an FPGA.

This makes them ideal for tasks where many different calculations can be made in parallel.

While some microcontroller processors have multiple cores, allowing several instructions to be executed simultaneously, in an FPGA, practically everything happens simultaneously.

So it's a bit like having a processor with thousands (or even millions) of cores; even though each of those cores may have fairly limited capabilities, overall it is a much more powerful and capable device.

A good example of a task which is quite easy to do with an FPGA but virtually impossible with a regular microcontroller, as demonstrated by the Arduino MKR Vidor 4000, is the generation of an HDMI digital video signal.

The FPGA can produce the HMDI data (which is typically clocked at the hundreds of megahertz) far quicker than any microcontroller could manage.

And it can do this while performing whatever other tasks are required simultaneously, without any concerns that the different tasks may interfere with the time-critical video generation process.

Rather than software code (eg, BASIC, C, assembly language etc), the FPGA configuration is described in a hardware description language (HDL). There are two main HDLs in widespread use: Verilog and VHDL.

We will mostly be dealing with Verilog, which as stated earlier, borrows some of its syntax from the C language; but due to the nature of FPGAs, it has some important and significant differences.

The HDL is synthesised into a 'bitstream' (basically, a blob of binary data), which is what is actually loaded into the FPGA chip to configure it. In the case of the iCE40HX-1k FPGA on the iCEstick, this is up to 34kB in size. The bitstream is roughly the equivalent of machine code to a microcontroller or microprocessor.

There is a lot more to this process than this simple description suggests, and much of how FPGAs and FPGA development tools work has been hidden by the manufacturers until the advent of the open source tools we are now using.

ICE40HX chip and iCEstick board capabilities

While touted as having a USB thumb drive form factor, it actually measures 95 x 25mm. But when you consider that a large portion of this board is taken up by the sizeable FPGA chip, its size seems reasonable.

This IC is a Lattice iCE40HX-1k FPGA which comes in a 144-lead TQFP package. While not all the input/output pins are broken out (the chip has 96 I/O pins in total), an ample number are available.

The iCE40HX-1k contains 1280 flip-flops, 1280 lookup tables, 160 programmable logic blocks and 16 RAM blocks. Each RAM block holds four kilobits (512 bytes), for a total of 8 kilobytes.

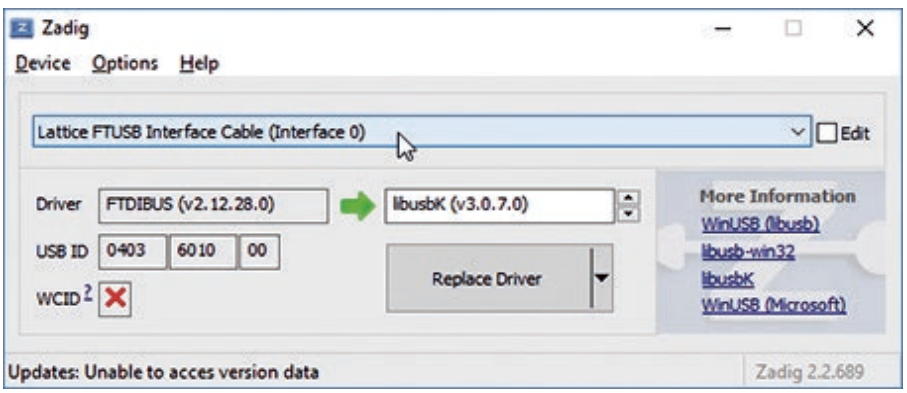
For comparison, its larger sibling, the iCE40HX-8k, can emulate a 32-bit RISC processor, but this is a bit beyond the iCE40HX-1k's capabilities.

The core of the chip runs at 1.2V, but external I/O on the iCEstick is 3.3V. There are four I/O banks on the iCE40HX-1k which can (in a different implementation) be set to other I/O voltages.

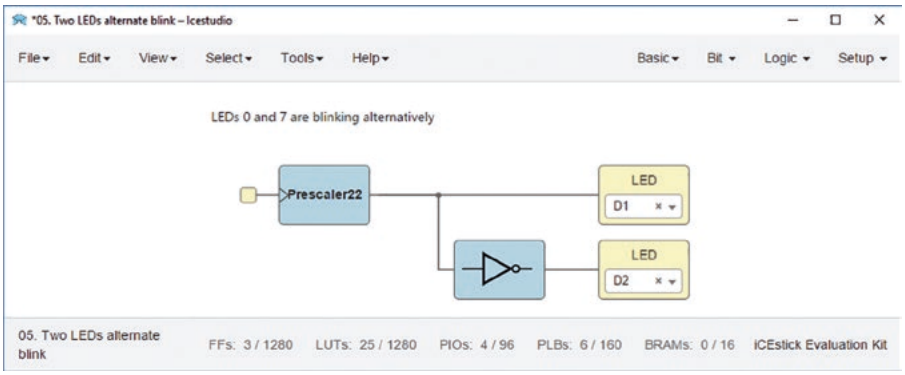
Also on the iCEstick board are several other components for communications and programming. The second-largest IC, nearest the USB plug, provides the USB interface.

This is an FTDI 2232H dual UART with USB 2.0 Hi-Speed. Typically, one of the UARTs is used in SPI mode for programming, and the second UART is available for communication with the bitstream that is 'running' on the FPGA.

The two 8-pin SOIC devices are a flash IC and an EEPROM IC. The flash IC is 32Mbit and is used to store the configuration bitstream in a non-volatile fashion. The FPGA is configured using internal RAM, the contents of which is lost on power-down, so it must be loaded from the flash chip each time



Screen1: ensure that the correct device is selected in the Zadig application, and that libusbK is selected before clicking "Replace" and closing the window. If you do change the wrong driver, you can uninstall it via device manager.



Screen2: IceStudio's "Two LEDs alternate blink" example (which they incorrectly refer to as "alternative"). The small yellow box at left represents the 12MHz crystal clock on the iCEstick. It is followed by a 22-stage binary divider, effectively dividing the 12MHz clock by a factor of 4,194,304 (ie, by 2^{22}, to around 3Hz). Digital pins D1 and D2 are connected to two LEDs on the iCEstick board, and are driven with square waves derived from the 3Hz clock, one directly, and one via a NOT gate so that it is on while the other is off.

power is applied.

While the FPGA has the facility to load its configuration from its own internal non-volatile configuration memory, this memory can only be programmed once, so a reprogrammable flash chip is used until a design is finalised.

The EEPROM is simply used to hold the configuration for the FTDI 2232H and the remaining IC is an LT3030 dual low-dropout linear regulator.

There is also a 12MHz clock source on the iCEstick. This clock source is necessary for all but the most basic logic designs.

The iCE40HX-1k also features a PLL, so designs are not limited to 12MHz, as higher frequencies can be generated by the PLL from the 12MHz source.

On the far side of the FPGA are the I/O breakout headers. Five LEDs (marked D1-D5) are arranged in a diamond pattern, flanked by two 0.1" pitch 10-pin breakouts. Each of these provides eight I/O pins plus ground and 3.3V power.

The 6x2 female header block matches Digilent's PMOD interface, and provides eight more I/Os, plus ground and power.

Finally, at the end of the board opposite the USB connector is an IR transceiver chip, which is connected to another two of the FPGA's I/O pins. This gives a total of 24 unallocated I/O pins available for use, plus at least ten dedicated to I/O functions on the board itself.

Other FPGA boards

After acquiring the iCEstick, we looked around for other FPGA development boards; in particular, those supported by IceStudio. Many of these are open-sourced hardware designs that are being promoted on crowd-funded websites.

In general, we found that most of them were more expensive than the iCEstick. A few were cheaper, but also required a separate programmer. So for this reason, and because the iCEstick is easy to buy in Australia, we decided to stick with it.

The fact that two different software packages can be used to program it is also a plus.

Software for the iCEstick

In the following discussion of the software options, we will only give very basic examples. If you want something more involved (and useful), see our iCEstick VGA Terminal Project, which starts on page 58.

There, we'll delve much deeper into what can be done with the iCEstick and IceStudio.

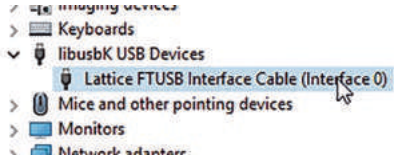
IceStudio software

The open-source IceStudio software is a free download. We found it straightforward to use, and had a working project uploaded to the board in minutes. There are example projects available which appear quite basic, but they are all great building blocks.

The version we tried was just over 100MB, although you also need to download some other required software packages, such as the 'toolchain'.

Installing IceStudio

IceStudio can be downloaded from its Github page at **https://github.com/FPGAwars/icestudio** Like many open source tools, it is available for Windows, Linux and macOS. We used the v0.4.0 release. Although this release number indicates it is still in beta, we found the software to be mature and didn't run into many bugs.



Screen3: if you need to remove IceStudio's drivers to allow the Diamond Programmer to work with the iCEstick then find this entry in Device Manager, right-click it and choose Uninstall Device. Unplug and replug the iCEstick and Windows should reinstall the default drivers.

Behind the scenes, it uses the open-source IceStorm project to synthesise the bitstream alongside some configuration files, but you don't need to concern yourself with these details while using IceStudio.

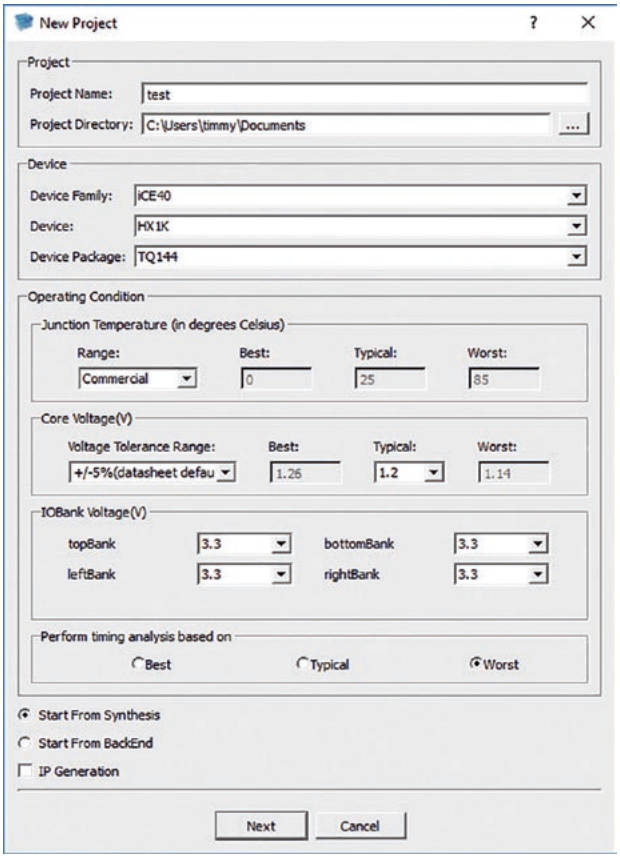
In this regard, it is similar to Arduino, which uses the open source gcc compiler and the AVRDUDE programming tool to provide most of its functions, with inbuilt board configuration files meaning the user does not have to worry about the minute details of the specific hardware used.

Installing IceStudio was quite straightforward. About halfway down the Github page (link above), there is an installation guide, with brief, simple instructions for Linux, Windows and macOS, with links to the downloads.

We installed on Windows 10, so some of the steps below may not apply to Linux or macOS; in particular, the driver switching step is probably not needed on these other operating systems.

The installer does not automatically install the required toolchain – you will be prompted to install it when the program first runs. No further input is required apart from confirming that installation should proceed.

IceStudio also includes a bitstream programmer, but this does not work with the default device driver for the iCEstick under Windows. Again, a simple tool allows the appropriate driver to be installed and uninstalled (which is necessary if you wish to also use Lattice's iCEcube software).



Screen4: this screen grab shows the iCEcube2 new project settings to suit the iCEstick. The project name and location can be set to suit your system, but the device properties are critical for correct operation.

The driver switcher uses the Zadig driver utility. IceStudio gives you some prompts which explain how to use Zadig, then opens the program, allows you to make the changes, and then prompts you to unplug and replug the iCEstick.

This is all fairly seamless, and it's comforting that the program is up-front about what changes you are making. The Zadig utility also has the option of changing other drivers, so great care should be taken that you don't inadvertently change the wrong driver.

We also noticed that, very occasionally, Windows would reload the old driver (perhaps when the iCEstick was plugged into a different USB port). In that case, it is merely necessary to rerun the driver switcher routine.

Setup

Once the installer has finished, start IceStudio. You will be prompted to install the toolchain, which requires the Python scripting language to be installed, plus a few other packages. If you are not prompted, check the Tools → Toolchain menu, and click Update if you are unsure. We found that this proceeded without any problems, though you need internet access to download these extra packages.

You will then be prompted to update the drivers. This is only possible if you have an iCEstick connected. If you don't have an iCEstick, skip this step. Again, there is no harm in checking the drivers if you are not prompted.

Now click Tools → Drivers → Enable. IceStudio will indicate a few steps that will occur. Click OK to proceed. Note the message about using USB 2.0 ports. We ran into problems using the iCEstick on a USB 3.0 port, but were able to use a USB 2.0 hub to 'downgrade' our connection to USB 2.0 and it worked after that.

When the Zadig Driver Utility opens (Windows may ask for permission for the program to make changes), take great care to change the correct drivers. Zadig has facilities for many drivers, but we only want to change those for the iCEstick.

Ensure that "Lattice FTUSB Interface Cable (Interface 0)" is selected in the dropdown and check that the item to the right of the green arrow is "libusbK" (in our case, version 3.0.7.0), then click "replace driver" (see Screen1).

IceStudio will now prompt you to unplug and replug the iCEstick. Do this to ensure the drivers are loaded correctly.

The final step is to select the development board. This is done from the Select → Board menu; the iCEstick is found under the HX1K subheading. Selecting the correct board means that friendly names are available for the various I/O pins. For example, a pin named "D1" can be selected, which maps directly to LED1 on the iCEstick.

This completes the setup. There are examples available under the File → Examples menu. Many of these appear to be written for other boards, but are simple enough to adapt for the iCEstick. The only real differences appear to be the I/O pin mappings, which are blanked on conversion.

We also suggest enabling the FPGA resources view, by clicking View → FPGA resources, and ensuring this item is ticked. The bottom bar of the window will now show the resource usage, which is empty at this stage. This will let you keep track of how 'full' your FPGA is.

Using IceStudio

A good place to start is the example available under the following menu: File → Examples → Basic → Two LEDs alternate blink.

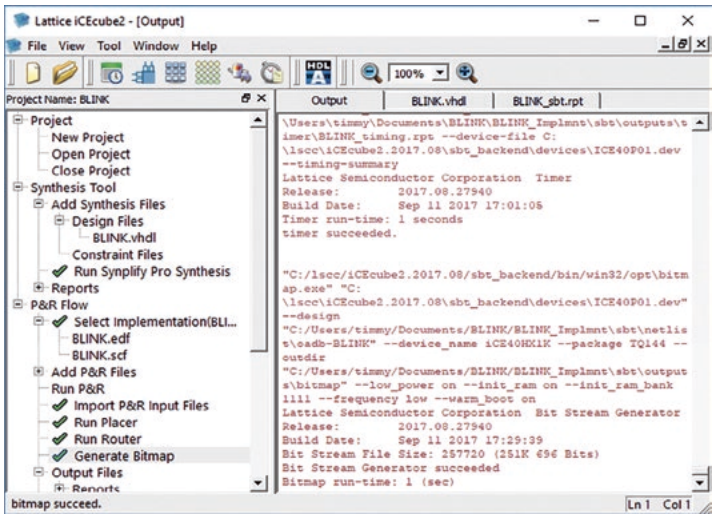
Upon opening this, you will be prompted that it is designed for a different board; simply click "convert". As mentioned above, conversion involves removing any I/O pins associated with the old board. To complete the conversion, click on the LED dropdown boxes, and select D1 and D2 (see Screen2).

The next step is to compile the project into a bitstream. Click Tools → Build or press Ctrl-B. After a few seconds, a message will pop up which should say "Build done". Finally, click Tools → Upload to send it to the iCEstick. The LEDs will all light up dimly during the upload stage, and if the upload is successful, two of the LEDs should be alternately flashing.

If you have trouble with the upload, check the drivers using the Enable Driver option or try a different USB port.

We recommend looking at the examples to see what can be done with IceStudio. The four menu items at top right are various items that can be dropped into the editor to create your project.

Included in these (under Basic) is a "Code" option. This allows blocks containing Verilog code to be included. For those familiar with Verilog, the blocks are effectively the same as Verilog modules. Such a code block



Screen5: the iCEcube window after our project has been converted into a bitstream. Despite all the red text, everything completed without errors. The Pin Constraints Editor is the icon below the left of the Window menu.

can even be exported and used in another project.

You can build just about any set of logic using Verilog, including adders, accumulators, multipliers, dividers, multiplexers, memories, register files and so on.

The various gates and other blocks can be joined by wires. To create a wire, move the mouse to an output pin of a block until the pointer becomes a black cross. Click, and drag the wire to the input of another block and release.

We found the wires to be one of the fiddliest parts of IceStudio. They can only be dragged from output to input, and often end up in awkward places. They can be dragged to neaten the layout or removed by hovering over the wire, and then finding the small red 'x' and clicking on it.

The software has all the usual editing facilities such as copy, paste and undo, and they all work rather well once you get used to it. You can press and hold the right mouse button to pan around the window, and the scroll wheel on the mouse allows zooming in and out.

A full user guide is available online at: **https://icestudio.readthedocs.io/en/latest/**

Note that if you have used IceStudio to enable its driver, you will need to disable it to allow the Diamond Programmer to use its driver. The Tools → Drivers → Disable menu is a bit cryptic about this.

What you need to do is open Device Manager, find the libusbK driver entry, right click on it and uninstall it (Screen3). Then unplug and replug the iCEstick, and Windows will reinstall the default drivers.

This isn't necessary on macOS or Linux, as the same drivers are used for both software packages.

iCEcube2

iCEcube2 is proprietary software, and while you can freely download it and install it, a license key is needed to run it. This is all available at no cost, but you will need to create an account on the Lattice website to receive a license key.

We found the process of setting up an account and requesting a key a bit slow, but it worked, and we got our key in the end.

The key is tied to a specific Ethernet MAC address, meaning you will need multiple licenses if you want to run the software on multiple computers. The iCEcube2 version we downloaded was around 750MB, and a separate download of the "Diamond" programmer application is needed too.

There are versions of iCEcube2 available for Windows and Linux, downloadable from: **http://siliconchip.com.au/link/aant**

The separate programmer software can be found at: **http://siliconchip.com.au/link/aanu**

Ensure that you have the license file for iCEcube2. There is a link on the information page for iCEcube2 detailing how to receive the license file via email. Although the email notes that the license file should be placed in the \license directory of our install, there did not appear to be such a directory.

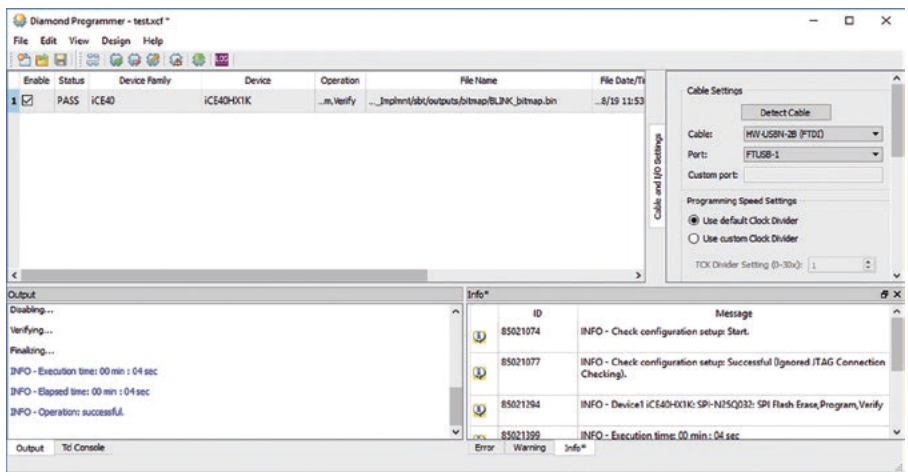
Our install of iCEcube2 has the path C:\lscc\iCEcube2.2017.08, so we placed a copy of the license in both the lscc and iCEcube2.2017.08 directories, and everything seemed to work, although it did sometimes complain that the license file was missing.

We struggled to find simple examples that would work for the iCEstick under iCEcube2, and certainly didn't find any on Lattice's website. In the end, we found a basic 'blink' example at **siliconchip.com.au/link/aanv**, but even this missed one or two steps, so we had to modify it.

ICEcube2 uses VHDL, so if you prefer VHDL over Verilog, this may be an option, although VHDL is generally stricter and more verbose than Verilog (Editor's note: in my opinion, Verilog is superior, although they both have roughly the same capabilities).

To use iCEcube2, first create a new project, and fill in the details as shown in the screen grab (Screen4), to match the hardware of the iCEstick. Click OK, and the 'add files' dialog box opens; click "Finish", as files can be added from within the project.

You can download the "BLINK.



Screen6: the Diamond Programmer window. Check the Device, Device family and Cable settings to ensure they are correct. The Device Properties icon is immediately below the Help menu item, while the Program button is the one with the large green arrow.

vhdl" file from the SILICON CHIP website, associated with this article, or search based on the year and month of publication. Copy this file to within the project folder, then add it to the project by right-clicking on "Add Synthesis Files". Select the file and then press the ">>" button to add it to the project.

The "Run Synplify Pro Synthesis" button is the first step in turning the project into a bitstream. Double-click this, and check that there are no errors. We got an error message about the license file, but it worked anyway.

Next click "Import P&R Input Files". You should see a pattern of working through several steps along the left-hand side of the project window, with the green triangles turning into ticks as the steps are completed by double-clicking on them (see Screen5).

After the P&R (place and route) files have been imported, the pins need to be assigned. This is done with the Pin Constraints Editor, selected from the row of icons below the menus. In our version, it is the fourth icon, which looks like a blue square with pins coming out of it.

The physical pin to I/O pin mapping is shown in Table 1. LED1 and LED2 should be set to pins 95 and 96 (or any of the other LED pins from the table), and "clk" (the clock signal input) should be set to pin 21. Save the project to register the new pin assignments.

Finally, in turn, double click "Run Placer", "Run Router" and "Generate Bitmap". The generated bitmap is the file that will be loaded onto the iCEstick. It can be found buried within the project folder, eg, \BLINK_Implmnt\sbt\outputs\bitmap\BLINK_bitmap.bin

Diamond Programmer

Now we use the Diamond Programmer application to load the bitstream onto the iCEstick. Open Diamond Programmer, select "Create a new blank project" and click OK.

Under "Cable Settings" to the right, click "Detect Cable"; the selected cable should include FTDI in its name. We found we had to set the port to FTUSB-1 (see Screen6).

In the main window, set the device family to iCE40 and the device to iCE40HX1K. Under File Name, browse to the bitmap file created by iCEcube2 and select it.

Click the "Device Properties" icon (a chip with a small yellow pencil) and set that as shown in the screen grab (Screen7). Finally, click the "Program" button to transfer the bitstream to the iCEstick.

If all is well, your Output Window at bottom left should look like our screenshot, and you should see two LEDs flashing alternately on the iCEstick.

Conclusion

We devoted more space to describing the iCEcube2 and Diamond Programmer software than IceStudio because it requires more work to achieve the same result.

We found that IceStudio was a real pleasure to use and would highly recommend it to anyone who has not worked with FPGAs before. We found a couple of small glitches, including occasional crashes even on quite small projects. So save your work often.

We also found IceStudio became quite sluggish on larger projects, taking some time to zoom and move around. We imagine that as we become more proficient with Verilog, that our IceStudio projects will consist of nothing more than a single large code block, which should not present the same performance issues as lots of smaller blocks.

IceStudio also appears to have the benefit of being written specifically for development boards such as the iCEstick.

If you are a professional developer, especially someone looking to build an FPGA into an end product, the flexibility and complexity of iCEcube2 will be warranted. Just choosing a different flash IC to that fitted or another small hardware change different to the iCEstick would probably be enough to hamper IceStudio in these cases.

With iCEcube2, once we had our project set up, everything worked quite well; similarly, Diamond Programmer worked quite well, although the time spent pulling hair and debugging cryptic error messages was quite a bit more than we had hoped.

But for someone who has not worked with FPGAs before, IceStudio will give a smooth, easy way for you to become accustomed to what is possible.

In terms of hardware, there are a few development boards around which feature more powerful FPGAs than the iCEstick.

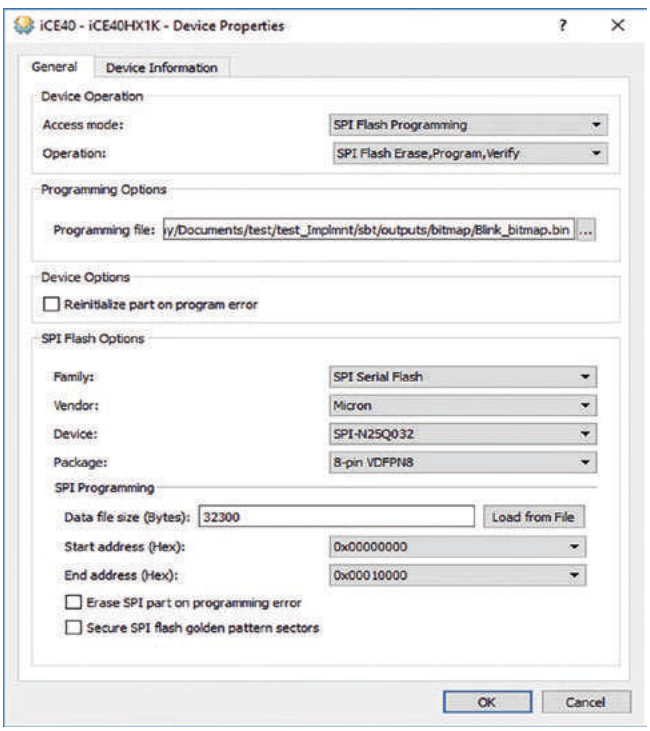
But for now, the iCEstick suits our purposes, and we think it will be a great starting point for those wishing to try out FPGAs for the first time.

The iCEstick is available from Mouser and Digikey; both offer free international express delivery for orders over AUD $60.

The iCEstick is around $30-40, so you could order two and get free delivery, or order one and something else.

Use the following links:

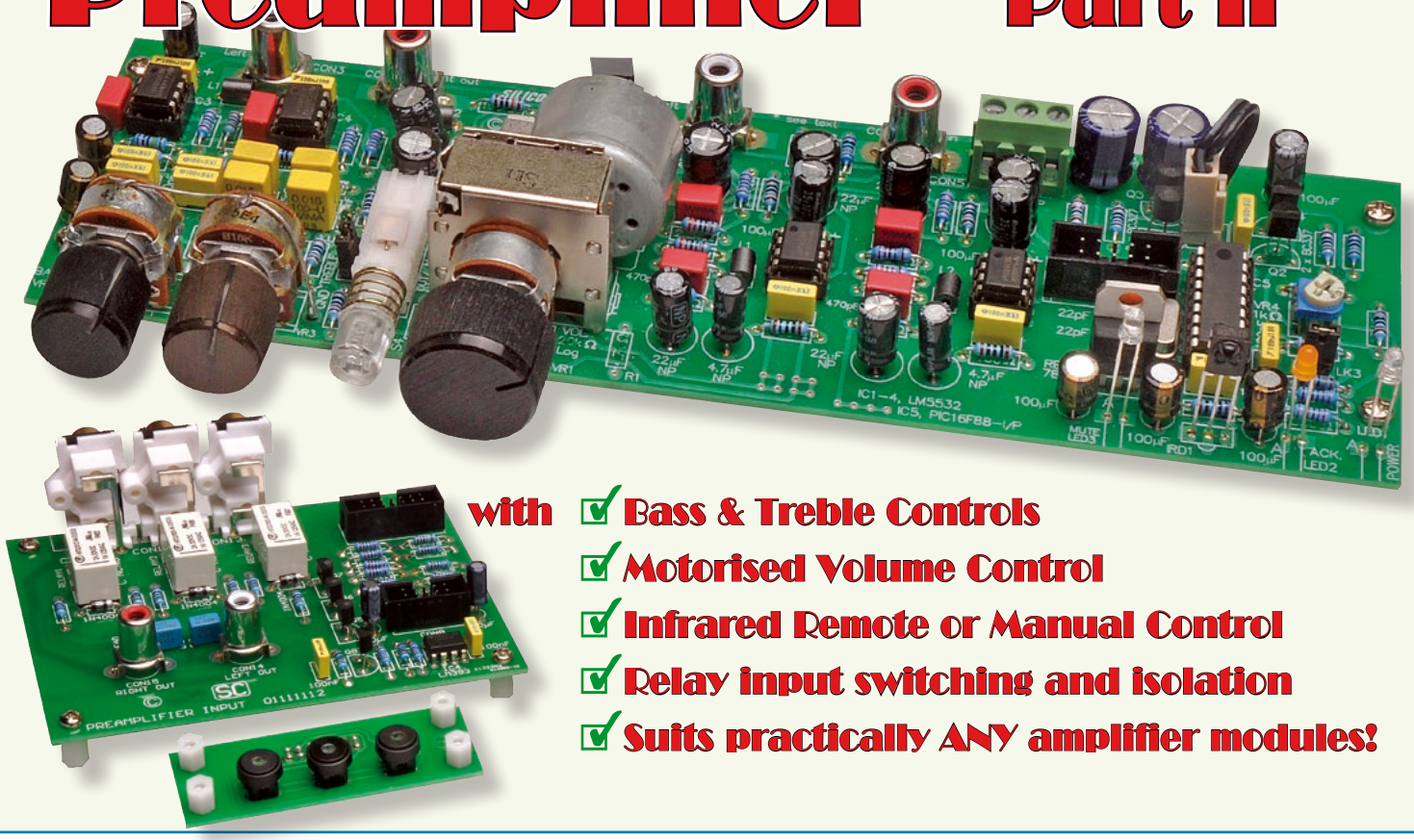
siliconchip.com.au/link/aao1
or
siliconchip.com.au/link/aao2



Screen7: we would never have guessed these properties, so we're glad we found a guide to help us out. Make sure you don't select NVCM programming. That is the non-erasable (write-once) memory built into the iCE40HX-1k IC. We use the flash memory instead, to allow repeated write/erase cycles.

Ultra Low Noise Preamplifier Part II

by John Clarke



with
- Bass & Treble Controls
- Motorised Volume Control
- Infrared Remote or Manual Control
- Relay input switching and isolation
- Suits practically ANY amplifier modules!

Last month, we introduced our state-of-the-art stereo preamplifier. Along with almost unmeasurable noise and distortion (typically 0.0003% THD+N!) it sports remote volume control, input selection and muting plus bass and treble adjustment knobs on the front panel. Now let's build the input selection boards and power supply.

The circuits of the optional input selector board and front-panel pushbutton board were shown in Figs.8 & 9 last month.

We also listed the parts required to build those two boards in that article.

Figs.10 & 11 show the PCB overlay diagrams for these two boards, so you can see how those parts are fitted.

By the way, you don't have to build either of these boards if you don't need the ability to select between more than one set of stereo inputs.

In that case, you would connect the chassis-mounted input sockets directly to CON1 and CON3 on the main preamp board.

And if you do want the input selector but only need the remote control feature, and don't want front panel pushbuttons/input indicators, you could build the input selector board (Fig.10) but not the front panel pushbutton board (Fig.11).

You can then use the remote control to select between the three inputs, although it won't show which is selected – you will have to remember the last selection you made.

Incidentally, we haven't listed all the features and specifications again – refer to the March issue for these and performance graphs. You'll agree, this is an outstanding performer!

Input selector construction

The input select board is easy to assemble. It's built on a double-sided PCB coded 01111112 which measures

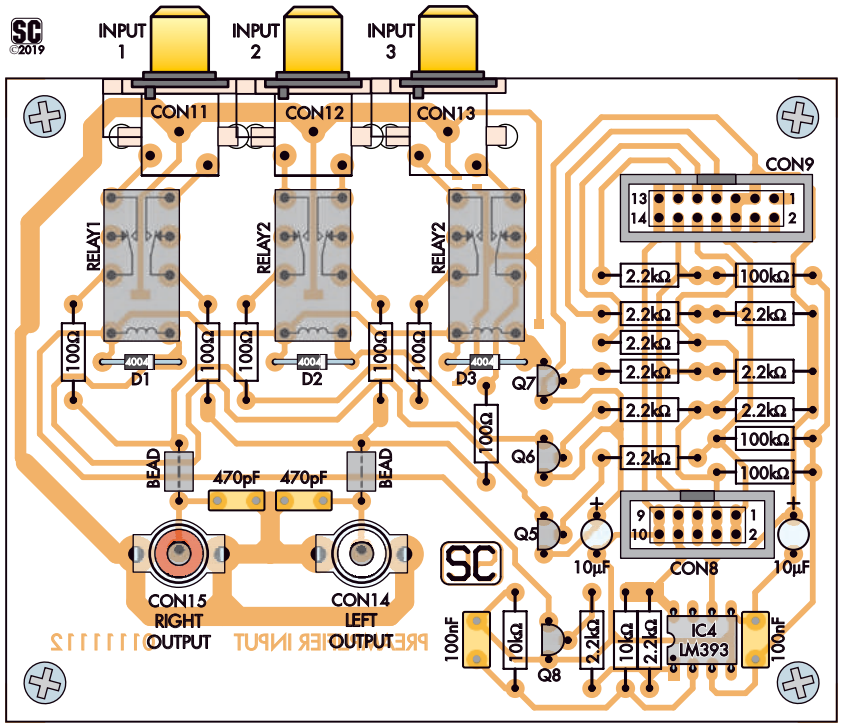


Fig.10 (left): follow this diagram to build the input selector PCB. Make sure that the two header sockets are correctly orientated and note that Q5-Q7 are BC327 PNP transistors while Q8 is a BC337 NPN transistor.

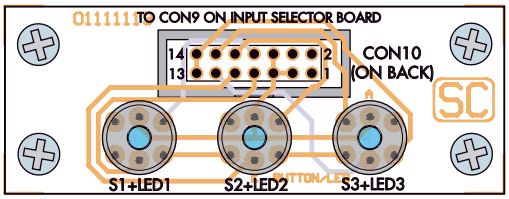


Fig.11 (below): the three switches are mounted on the front of the pushbutton board while the header socket goes on the back (key-way towards S2). Take care with the switch orientation (see text): the six pins for each switch are for the switch contacts themselves (four) plus two for the integral LEDs.

110 x 85mm.

Start by fitting the resistors where shown. We published the resistor colour codes last month but it's always best to check the values with a DMM set to measure resistance to make sure they're going in the right places.

Follow with diodes D1-D3, ensuring that their cathode stripes face as shown, then feed some resistor lead offcuts through the ferrite beads and solder them in place.

We recommend that you solder IC4 directly to the board, although you can use a socket if you really want to.

Either way, make sure its pin 1 dot/notch faces to the left, as shown. Fit the MKT/MKP/ceramic capacitors next.

We explained in detail last month why there are three different options for the 470pF capacitors, and that if you use ceramics, they must be NP0/C0G types for good performance.

We used MKTs on our prototype. Mount them, plus the two 100nF MKTs now.

Next solder the four transistors, noting that Q5-Q7 are BC327s while Q8 is a BC337. The two electrolytics can then go in, with the longer positive leads through the holes marked "+", followed by the 10-way and 14-way header sockets, CON8 and CON9.

These sockets must be installed with their slotted key-ways towards the top.

Finally, complete the assembly by installing the relays, the three stereo RCA input sockets and the two vertical RCA output sockets.

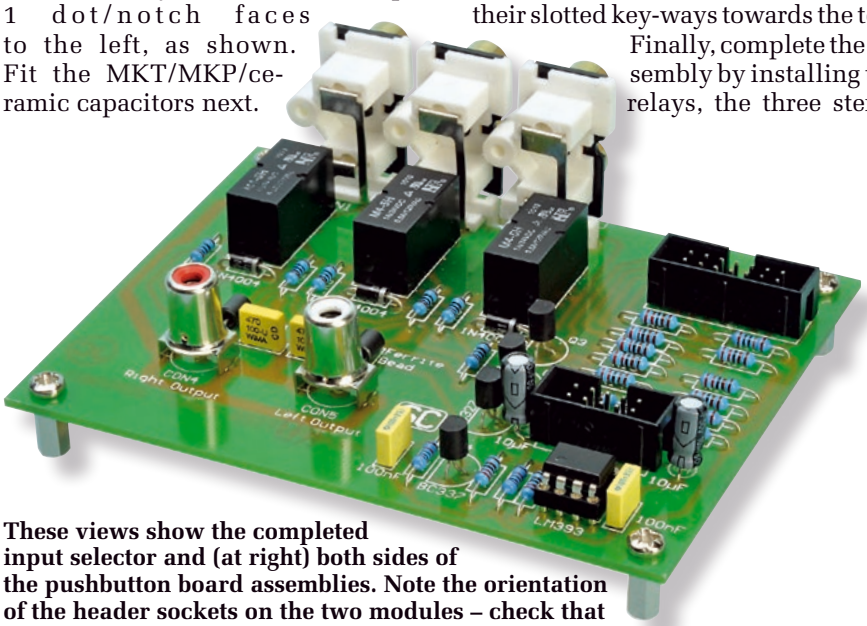
Note the left and right labelling for the output sockets – this is not a mistake and arranging them this way gives the optimum layout for the PCB.

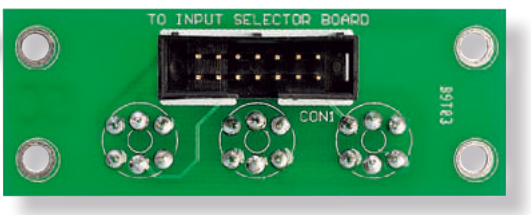
Front panel pushbutton board assembly

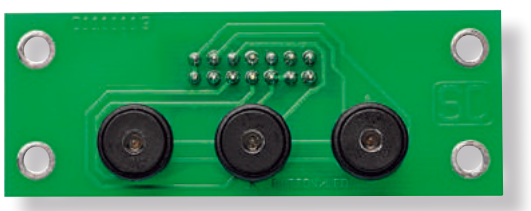
There just four parts on the pushbutton board – the three pushbutton switches on one side and the 14-way IDC header socket on the other (see Fig.11 above). The board is coded 01111113 and it measures 66 x 25mm.

The three pushbuttons can go on first but note that they must be installed the right way around.

These have "kinked" pins at each corner plus two straight pins for the







These views show the completed input selector and (at right) both sides of the pushbutton board assemblies. Note the orientation of the header sockets on the two modules – check that these sockets, the relays, the RCA sockets and the button switches are all sitting flush against their respective PCBs before soldering their leads.

integral blue LED. The anode pin is the longer of the two and this must go in the hole marked "A" on the PCB (towards the header).

Once the pins are in, push the buttons all the way down so that they sit flush against the PCB before soldering their leads.

The IDC header socket can then be installed on the other side of the board, with its key-way notch towards the bottom.

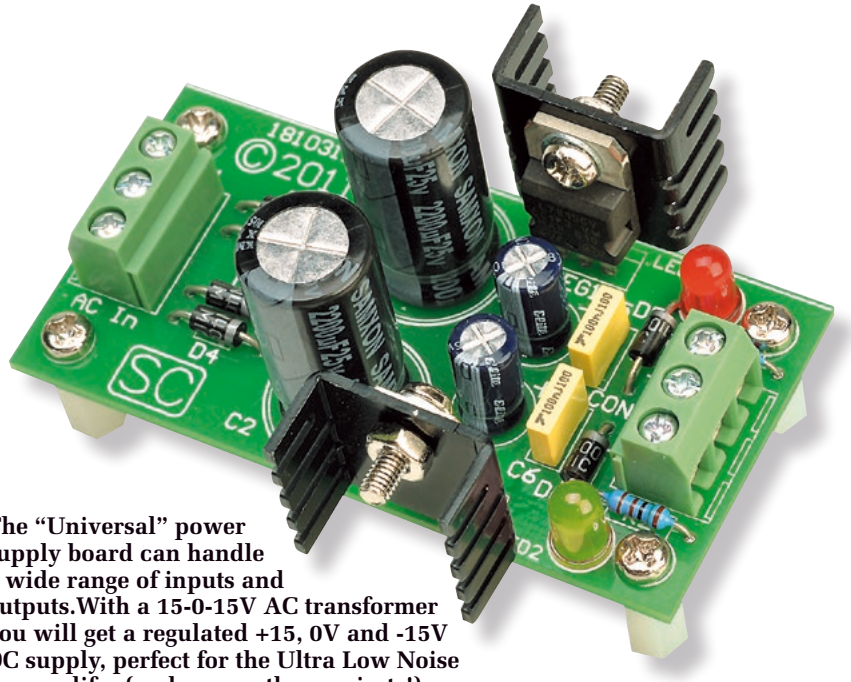
Choice of power supply

If you are building this preamp as part of a full amplifier, the chances are you will already have a suitable power supply which produces the required ±15V DC rails. Otherwise, we mentioned a few different suitable power supply boards last month.

That includes the March 2011 Universal Regulator (siliconchip.com.au/Article/930) [available as a Jaycar kit, Cat KC5501] and the Ultra-LD Mk.2/3/4 power supply board, last described in the September 2011 issue (siliconchip.com.au/Article/1160). In case you don't have those magazines, we'll quickly cover building both of those supplies here.

The Universal Regulator is a good choice if you're building a standalone preamplifier, or building the preamp into an amplifier which already has a power supply but doesn't have ±15V DC rails.

The Ultra-LD power supply is best if you are building the preamp into a complete amplifier that you're making from scratch.



The "Universal" power supply board can handle a wide range of inputs and outputs.With a 15-0-15V AC transformer you will get a regulated +15, 0V and -15V DC supply, perfect for the Ultra Low Noise Preamplifer (and many other projects!).

Building the universal regulator

Fig.12 shows the circuit of the Universal Regulator while Fig.13 is the PCB overlay.

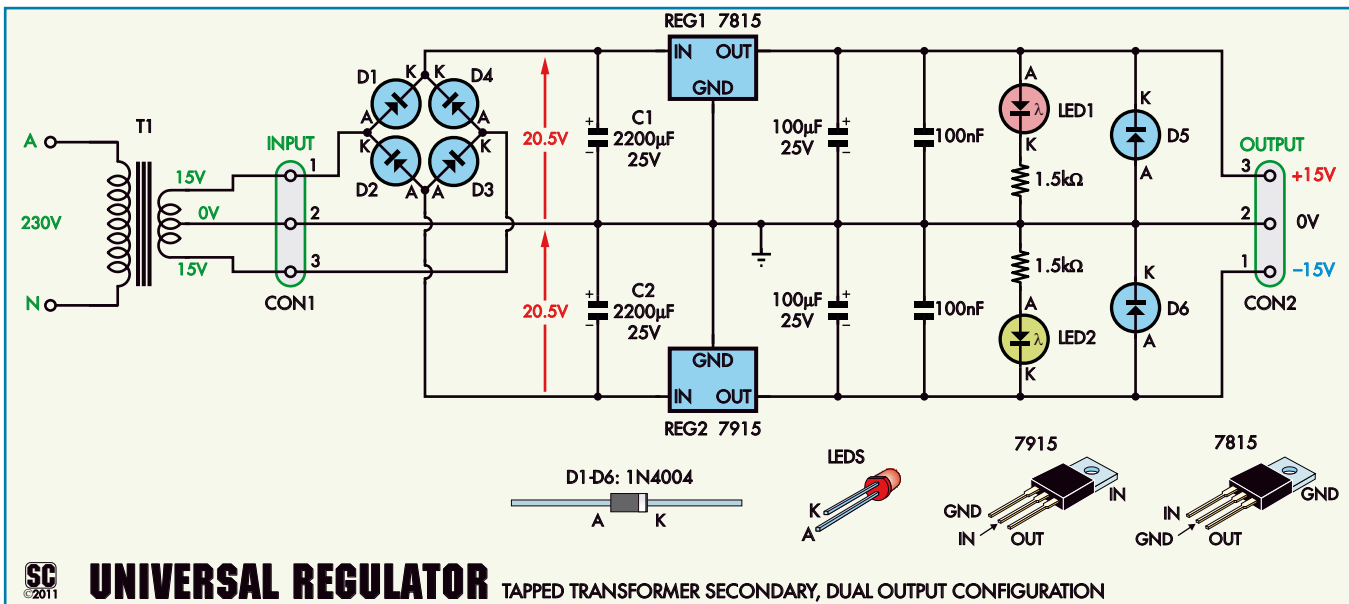
You can power it from a 30V centre-tapped transformer secondary (15-0-15V) or a single 15V winding.

The centre-tapped option is better if you can swing it, since it results in a lower ripple at the regulator inputs.

The AC output of the transformer is rectified by a bridge formed by diodes D1-D4 and filtered by a pair of 2200µF capacitors.

It's then regulated to +15V by REG1 and -15V by REG2. These regulated rails are available from terminal block CON2, which is then wired to the preamp.

It's built on a board coded 18103111 which measures 71 x 35.5mm. You can get this from the SILICON CHIP ONLINE



SC ©2011 **UNIVERSAL REGULATOR** TAPPED TRANSFORMER SECONDARY, DUAL OUTPUT CONFIGURATION

Fig.12: the Universal Regulator circuit generates ±15V rails. Diodes D1-D4 form a bridge rectifier, while capacitors C1 & C2 filter the rectified AC. Regulators REG1 & REG2 provide a steady output voltage while LED1 and LED2 indicate operation. You can also use a transformer with a single secondary (or a plugpack) connected between pins 1 & 2 or 2 & 3 of CON1.

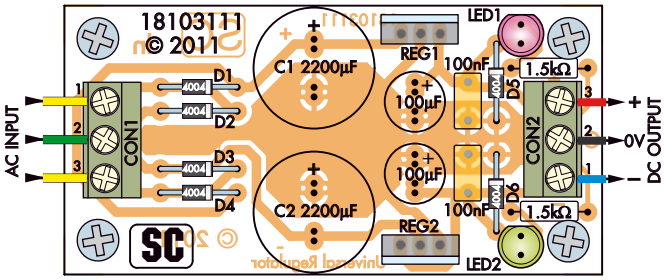


Fig.13: this PCB overlay corresponds with the circuit of Fig.12. You could fit flag heatsinks to REG1 & REG2 but they are not strictly necessary for use with the preamp, as it doesn't draw a lot of current.

SHOP (SC0782) or, if you purchase the kit from Jaycar, the PCB will be included.

See below for the list of parts you'll need to build it.

Start assembly by fitting the the two resistors and then the six diodes (with the polarity shown in Fig.13).

Next, mount the LEDs with the longer (anode) leads towards the bottom of the board. Follow with the two MKT capacitors.

You can then fit the two 3-way terminal blocks, with the wire entry holes facing the nearest edge of the board.

Now solder REG1 & REG2 with the tabs towards the board edge as shown, taking care not to get the two mixed up. Finally, solder the four capacitors in place, ensuring that their longer (positive) leads go into the pads marked with a "+" symbol.

The photo above shows two flag heatsinks (and they are mentioned in the parts list). It won't hurt to fit these, but if you're only going to be powering the preamplifier and your transformer secondary voltage is the recommended value, they should not be necessary since the preamp doesn't draw a lot of current.

Building the full power supply

The circuit of the Ultra-LD power supply is shown in Fig.14. The bottom section is similar to the Universal Regulator supply described above and operates in the same manner. A chassis-mount bridge rectifier is used for the high-voltage AC secondaries of the power transformer, which are shown as 40-0-40V here, but lower voltages can be used with this board too.

The resulting DC rails are then filtered by three 4700µF capacitors each and made available at CON1 and CON2, to be fed to the amplifier modules.

Fig.15 is the PCB overlay for this supply. You can purchase this PCB from the SILICON CHIP ONLINE SHOP (SC0716) The two wire links should not be necessary as our boards are double-sided and have copper strips on the top layer connecting these points, but if you etch a single-sided board, you will need to fit the two links using 1mm diameter tinned or enamelled copper wire.

Next, mount the diodes with the orientation shown, then the LEDs, with the longer (anode) leads towards the top of the board. You can then bend the regulator leads to fit the hole pattern on the PCB and attach their tabs to the board securely using M3 machine screws and nuts.

Once you've checked that they are straight, solder and trim the leads.

The terminal blocks go in next. Dovetail CON4 with

Parts list for Universal Regulator (±15V outputs)

1 PCB, code 18103111, 71 x 35.5mm
1 transformer, 230V AC primary, 15-0-15V AC or 230V AC to 15V AC plugpack to suit (see text)
2 3-way terminal blocks, 5.08mm pitch
4 tapped spacers
4 M3 x 6mm machine screws
2 TO-220 heatsinks (optional)
2 M3 x 10mm machine screws, nuts and shakeproof washers for heatsinks (optional)

Semiconductors
1 7815 +15V linear regulator
1 7915 -15V linear regulator
6 1N4004 diodes
1 red 5mm LED
1 green 5mm LED

Capacitors
2 2200µF 25V electrolytics
2 100µF 25V electrolytics
2 100nF MKT

Resistors (all 0.25W 1% metal film)
2 1.5kΩ

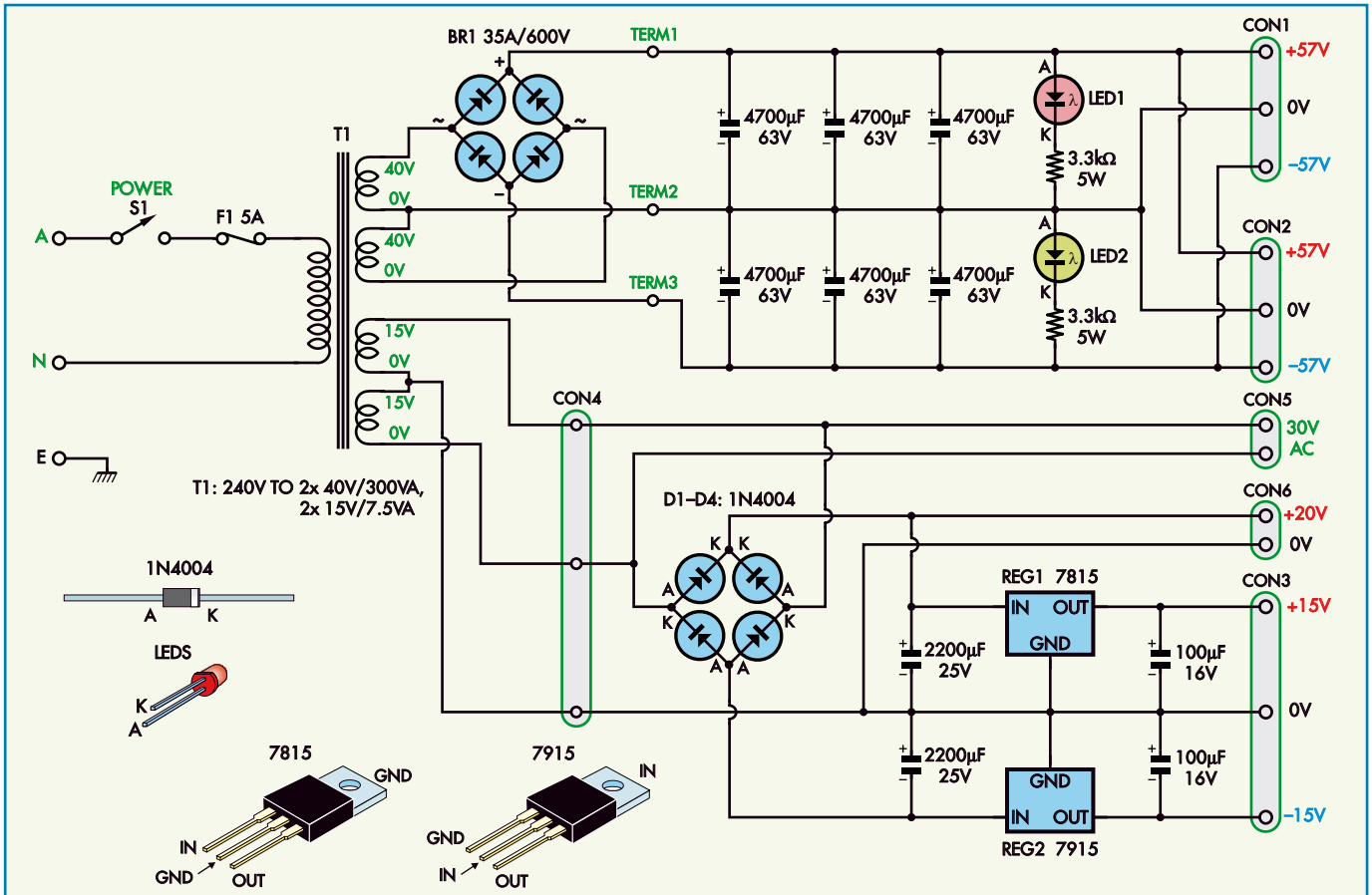
Parts list for Ultra-LD Amplifier and preamplifier power supply (±57V and ±15V outputs)

1 PCB, code 01109111, 141 x 80mm
1 transformer, 40-0-40V and 15-0-15V AC secondaries (see text)
4 3-way PCB-mount terminal blocks, 5.08mm pitch (Altronics P2035A or equivalent) (CON1-4)
2 2-way PCB-mount terminal blocks, 5.08mm pitch (Altronics P2034A) (CON5-6)
3 PCB-mount or chassis-mount spade connectors [Altronics H2094]
3 M4 x 10mm screws, nuts, flat washers and shakeproof washers (if using chassis-mount spade connectors)
4 M3 x 9mm tapped Nylon spacers
6 M3 x 6mm machine screws
2 M3 shakeproof washers and nuts
150mm 0.7mm diameter tinned copper wire

Semiconductors
1 35A 400W chassis-mounting bridge rectifier (BR1)
1 7815 1A 15V positive linear regulator (REG1)
1 7915 1A 15V negative linear regulator (REG2)
4 1N4004 1A diodes (D1-D4)
1 5mm green LED (LED1)
1 5mm red LED (LED2)

Capacitors
6 4700µF 63V electrolytic
2 2200µF 25V electrolytic
2 220µF 16V electrolytic

Resistors
2 3.3kΩ 5W



POWER AMPLIFIER & PREAMPLIFIER POWER SUPPLY

Fig.14: this amplifier power supply is based on a toroidal transformer (T1) with two 40V windings and two 15V windings, but you could use two separate transformers if necessary. You can use a transformer with lower voltage main secondary windings (ie, less than 40V) to achieve a lower amplifier supply voltage, without making any changes to the board.

CON5 and CON3 with CON6 before soldering them in place, with the wire entry holes facing towards the nearest edge of the board. Then you can mount the two 5W resistors, with their bodies a few millimetres above the PCB surface to allow cooling air to circulate.

Next install the spade connectors. If using the vertical type with two pins, push these into the board and solder them in place – you will need a hot iron to do this. If us-

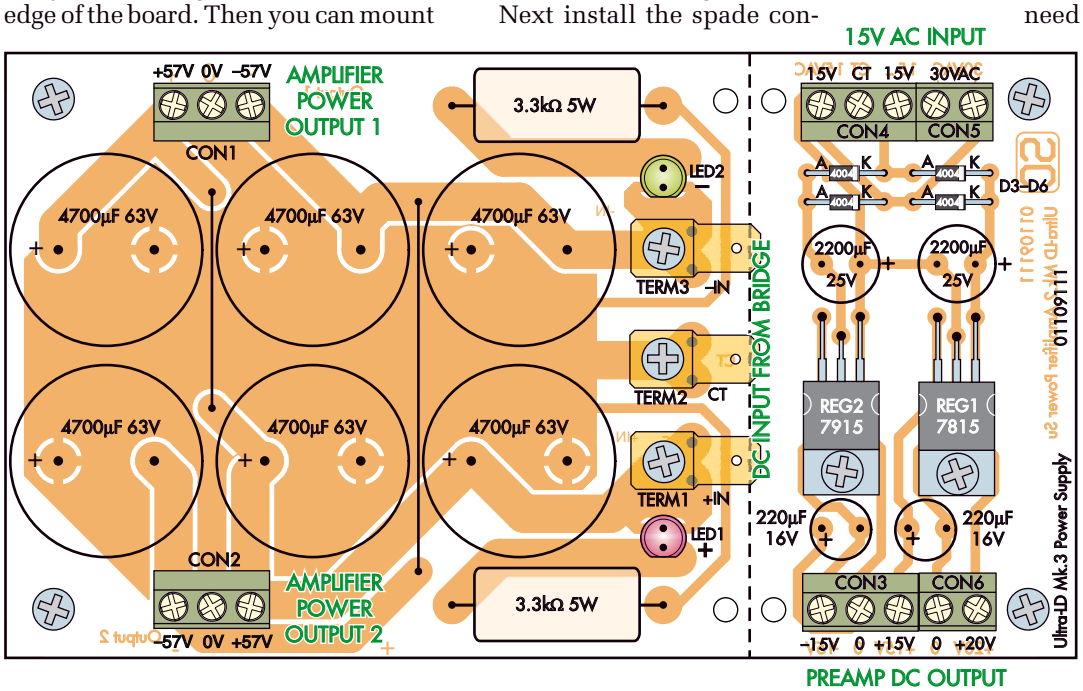
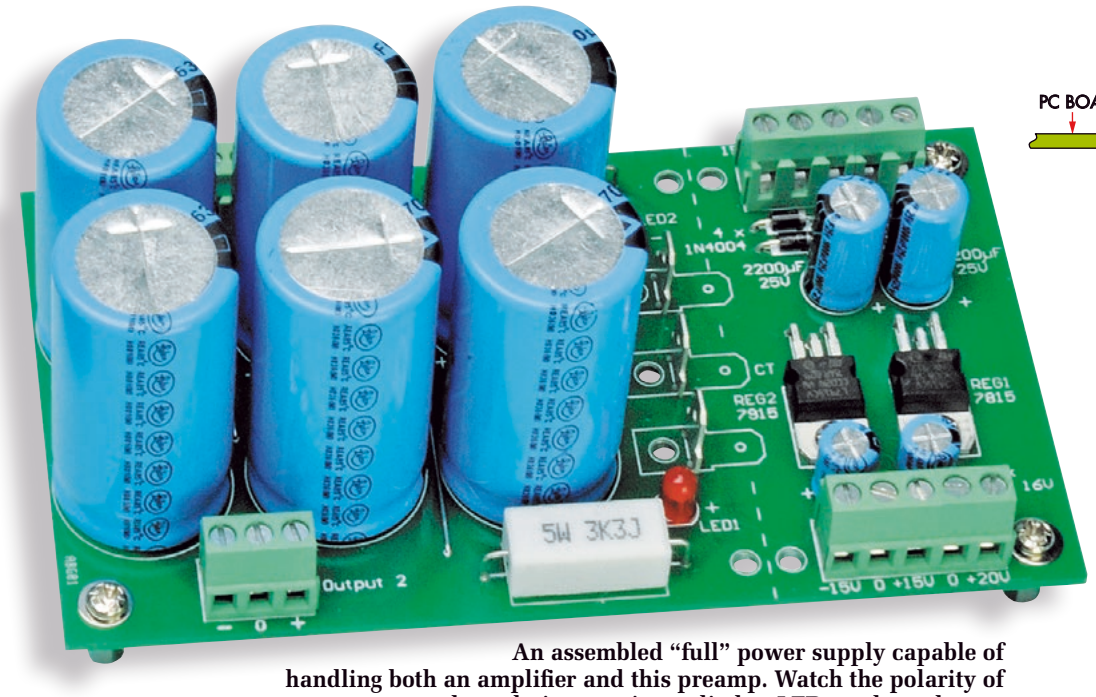


Fig.15: install the parts on the power supply board as shown here, taking care to ensure that all the electrolytic capacitors are mounted with the correct polarity. Be sure also to use the correct regulator at each location. The two LEDs indicate when power is applied and remain lit until the 4700µF capacitors discharge after switch-off.



An assembled "full" power supply capable of handling both an amplifier and this preamp. Watch the polarity of electrolytic capacitors, diodes, LEDs and regulators.

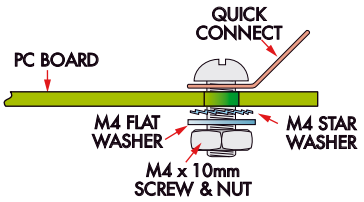


Fig.16: here's how the single-ended male spade quick connectors are secured to the power supply PCB. Vertical spade terminals with solderable pins can also be used.

ing the chassis-mounting type, attach them to the board using the specified M4 machine screws and nuts, as shown in Fig.16.

Now all that's left is to solder the small electrolytics capacitors in place, followed by the large ones. In both cases, the longer (positive) leads must go into the pads marked with a "+" on the PCB.

Initial checks

Before installing the three ICs on the preamp board, it's a good idea to check the supply voltages. You will need to wire up a transformer to your power supply, then connect the power supply's +15V, 0V and -15V outputs to the relevant inputs on the main preamplifier PCB.

It's safer to use a 15VAC plugpack for testing if you don't already have the transformer and power supply installed in an Earthed metal chassis. Just connect one wire from the plugpack output to either of the low-voltage AC input terminals on the power supply board, and the other wire to the centre tap transformer connection point.

Plug the plugpack into a GPO and switch it on. Now check the voltages on pins 8 & 4 of the four 8-pin IC sockets (IC1-IC4) on the preamp board; ie, between each of these pins and the 0V (centre) terminal of CON6. You should get readings of +15V and -15V respectively.

Similarly, check the voltage on pin 14 of IC5's socket. It should be between +4.8V and +5.2V.

If these voltages are correct, switch off and install the ICs. Note that IC1-IC4 face one way while microcontroller IC5 faces the other way.

Remote control/switch testing

The remote control functions can

Making the interconnecting cables

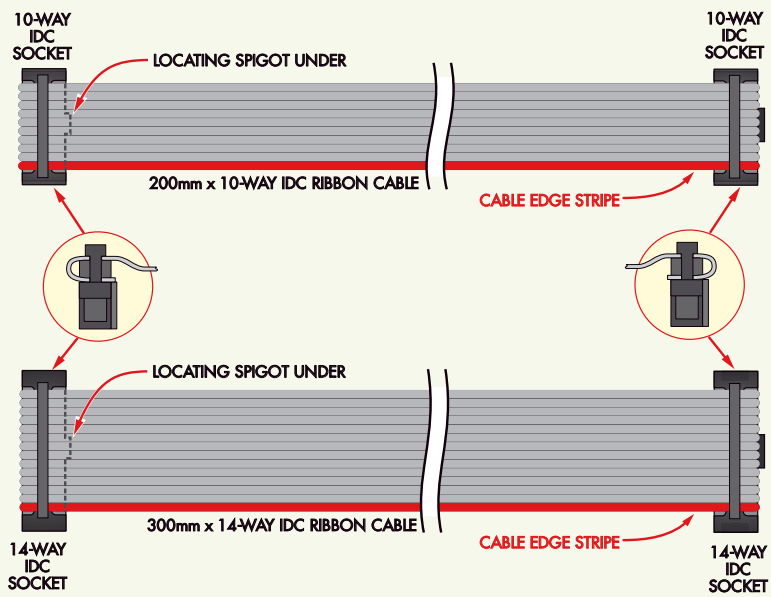
To connect the three boards, you need to make two IDC cables. These diagrams show how these cables are made.

Pin 1 on the header sockets is indicated by a small triangle in the plastic moulding and the red stripe of the cable must always go to these pins.

You can either crimp the IDC headers to the cable in a vice or use an IDC crimping tool (eg, Altronics T1540 or Jaycar TH1941).

Don't forget to fit the locking bars to the headers after crimping, to secure the cable in place.

Having completed the cables, it's a good idea to check that they have been correctly terminated. The best way to do this is to plug them into the matching sockets on the PCB assemblies and then check for continuity between the corresponding pins at either end using a multimeter.



Selecting The Mode and Programming The Remote

As stated in the text, it's necessary to program the universal remote control correctly. By default, the microcontroller's RC5 code is set to TV but SAT1 or SAT2 can also be selected. Just press and hold button S1 on the pushbutton board during power-up for SAT1 or button S2 for SAT2. Pressing S3 at power-up reverts to TV mode.

Once you've chosen the mode or "device", the correct code must be programmed into the remote. This involves selecting TV, SAT1 or SAT2 on the remote (to agree with the microcontroller set-up) and then programming in a three or 4-digit number for a Philips device. That's because most Philips devices (but not all) use the RC5 code standard that's expected by the Preamplifier.

Most universal remote controls can be used, including the model shown above, the Altronics A1012 ($29.95) and the Jaycar AR1955 ($29.95) or AR1954 ($39.95). For the Altronics A1012, use a code of 023 or 089 for TV mode, 242 for SAT1 or 245 for SAT2.

Similarly, for the Jaycar remotes, use code 1506 for TV, 0200 for SAT1 or 1100 for SAT2.

In the case of other universal remotes, it's just a matter of testing the various codes until you find one that works. There are usually no more than 15 codes (and usually fewer) listed for each Philips device, so it shouldn't take long to find the correct one.

Note that some codes may only partially work, eg, they might control the volume but not the input selection. In that case, try a different code. Also, some remotes may only work in one mode (eg, TV but not SAT).

now be tested using a suitable universal remote, eg, Altronics A1012. As stated earlier, the default device mode programmed into the micro is TV but if this conflicts with other gear you can choose SAT1 or SAT2 as the device instead.

Whichever mode is chosen, you must also program the correct code into the remote (see panel).

Note that if you don't have a split rail power supply ready yet, you can still check the remote control functions by using a single 9-15V DC supply connected between the +15V and 0V terminals of CON6 (watch the polarity).

As before, check the voltage on pin 14 of IC5's socket (it must be between +4.8V and +5.2V), then switch off and install IC5 (pin 1 towards IRD1). Also, insert the jumper link for LK3 to enable the mute return function

Now connect the three boards using the ribbon cable assemblies. The connectors are all keyed so as long as you plug the 10-wire cable into the 10-pin sockets and the 14-wire cable into the 14-pin sockets, everything should be connected properly.

Next, rotate VR2 fully anticlockwise and use the remote to check the various functions. First, check that the inputs can be selected using the 1, 2 & 3 buttons on the remote and the S1-S3 buttons on the pushbutton board. Each time a button is pressed, you should hear a "click" as its relay switches on and the blue LED in the corresponding switch button should light.

Also, the orange Acknowledge (ACK) LED should flash each time you press a button on the remote. If the ACK LED doesn't flash, make sure the code programmed into the remote matches the device mode (ie, TV, SAT1 or SAT2). The ACK LED won't flash at all unless the code is correct.

Now check that the volume pot turns clockwise when the Volume Up and Channel Up buttons are pressed and anti-clockwise when Volume Down and Channel Down are pressed. It should travel fairly quickly when Volume Up/Down buttons are pressed and at a slower rate when the Channel Up/Down buttons are used.

If it turns in the wrong direction, reverse the leads to the motor.

Adjusting trimpot VR2

Next, set the volume control to mid-position, set VR2 fully anti-clockwise and hit the Mute button. The pot will rotate anti-clockwise and as soon as it hits the stops, the clutch will start to slip.

While this is happening, slowly adjust VR2 clockwise until the motor stops. Now press Volume Up to turn the potentiometer clockwise for a few seconds and press Mute again. This time, the motor should stop as soon as the pot reaches its anticlockwise limit.

A programmed time-out of 13 seconds will also stop the motor if it continues to run after Mute is activated. This means that you have to adjust VR2 within this 13s period. If the motor stops prematurely or runs for the full 13s after the limit is reached, try redoing the adjustment.

Troubleshooting

If the unit fails to respond to remote control signals, check that the remote is in the correct mode (TV, SAT1 or SAT2) and has been correctly programmed.

If you're using a remote other than those listed in the panel, work through the different codes until you find one that works. Start with codes listed under the Philips brand as these are the most likely to work.

If the unit responds to the 1, 2 & 3 buttons on the remote but the button switches don't work, check that the ribbon cable to the pushbutton board has been crimped properly. Similarly, if the remote volume function works but not the remote input selection, check the cable from the Preamplifier board to the input selector board.

Note that the cable from the Preamplifier board also supplies power to the other two boards.

So it's worthwhile checking that there is 5V between pins 8 & 4 of IC4 on the Selector Board and again check the ribbon cable if this supply rail is missing.

Audio testing

If you are using a ±15V supply for testing, you can test the preamplifier further by connecting its outputs to a stereo amplifier and feeding in audio signals from a mobile phone, tablet, iPod, CD/DVD/Blu-Ray player or just about any other source.

Depending on your device, you may need a cable with a 3.5mm stereo plug at one end and red/white RCA plugs at the other end to make the connection. These are commonly available. SC

new catalogue out now

hardcore electronics by **jaycar**

On sale 24 March to 23 April, 2019

JUST $4.95

FREE catalogue*
for Nerd Perks Members with purchases of $30 or more.
Applies to new & existing members for purchases made in-store or online. Valid 1st April - 23 April.

Welcome Concord!

Concord, the new name in high tech video surveillance has arrived, offering a collection of high quality video surveillance and AV products at value prices, all with features that were previously only available on high end or commercial products.

We offer a range of DVR and NVR kits for you to select as well as additional cameras to upgrade and expand your kit.

All CCTV kits feature:

DROPBOX STORAGE | **THERMAL DETECT** | **IP67 RATING**

FROM **$399** 1TB HDD 1080p CONCORD

1080p DVR kits with 4 x 1080p PIR cameras

Perfect entry level camera kit for small home or office
- Smart viewing and notification
- PIR motion detection
- Built-in infrared LEDs for night vision up to 15m

4 Channel QV5000 **$399**
8 Channel Expandable to 8 cameras QV5002 **$499**

All CCTV kits includes DVR (or NVR) cameras, cables, adaptor and mouse.

DVR KITS

FROM **$799** 2TB HDD 4K UHD

4K DVR kits with 4 x PIR cameras

- Smart viewing and notification
- PIR motion detection
- Expandable up to 8 cameras
- Built-in infrared LEDs for night vision up to 20m

8 Channel with 4 x 5MP PIR cameras QV5100 **$799**
8 Channel with 4 x 4K PIR cameras QV5200 **$999**

view from your mobile device!

JUST **$599** 1TB HDD 1080p

1080p DVR Kit with 6 x 1080p PIR cameras

8 Channel. Expandable up to 8 cameras.
- Smart viewing and notification
- PIR motion detection
- Built-in infrared LEDs for night vision up to 15m

QV5004

FROM **$69.95**

Spare PIR & IP cameras to suit these DVRs & NVRs available. *See website for details.*

QC5020

NVR KITS

- **PIR MOTION DETECTION**

JUST **$699**

1080p wireless NVR kit with 4 x 1080p PIR IP cameras

4 Channel. Uses wireless camera perfect for renters.
- Smart viewing and notification
- PIR motion detection
- Built-in infrared LEDs for night vision up to 20m

QV5500

1TB HDD 1080p Wireless

FROM **$999**

- **PERIMETER & INTRUSION DETECTION**
- **FACE DETECTION**
- **CROSS-COUNTING**

4K NVR kits with 4 x PIR IP cameras

- Smart viewing and notification
- Audio Recording
- Power-over-Ethernet
- Expandable up to 8 cameras
- Built-in infrared LEDs for night vision up to 30m

8 Channel with 4 x 5MP cameras QV5600 **$999**
8 Channel with 4 x 4K cameras QV5700 **$1399**

2TB HDD 4K UHD

Shop the catalogue www.jaycar.com.au 1800 022 888

what is an IP camera?

An IP camera is a networked digital camera that transmits data over a fast Ethernet link. IP cameras (also called "network cameras") are most often used for IP surveillance, a digitized and networked version of closed circuit television (CCTV). The benefits of IP cameras over analogue technology include:

- Remote administration from any location
- Digital zoom
- The ability to easily send images and video anywhere with an Internet connection
- Progressive scanning, which enables better quality images extracted from the video, especially for moving targets
- Adjustable frame rates and resolution to meet specific needs
- Two way communications
- The ability to send alerts if suspicious activities are detected
- Lower cabling requirements
- Support for intelligent video

1080p Wi-Fi IP Cameras

These all feature:
- **2-way audio communication**
- **Full HD 1080p recording**
- **IR for day/night use**
- **Motion detection with notification push**
- **30 second alert video to your device.**

ALL JUST $129ea

With Pan/Tilt

Free iOS™ and Android app to remotely access the camera, pan, tilt, review footage, etc. using your Smartphone, iPad or Android tablet.
QC3858 **JUST $129**

Wi-Fi NEW amazon alexa ENABLED

NOW $69.95

SAVE $30

Wi-Fi

720P Wi-Fi IP camera with infrared LEDs

Intelligently engineered with ultra-easy pairing setup. 2-way audio communication - so it can be used for access control functions. IR LEDs for night time use. Includes USB mains power adaptor and USB charging cable.
QC3849 **ORRP $99.95**

OUTDOOR USE

With Infrared Illumination

Using the free iOS™ and Android Smartphone app you can connect to the camera and adjust camera parameters, review footage, etc.
QC3856 **JUST $129**

amazon alexa ENABLED Wi-Fi NEW

FROM $9.95

SAVE UP TO $10

LA5332

Dummy cameras

A simple and effective visual deterrent. Genuine-looking LEDs.
Dome with CCTV sticker
LA5332 **WAS $14.95 NOW $9.95 SAVE $5**
Bullet with Infrared LEDs
LA5325 **WAS $24.95 NOW $19.95 SAVE $5**
2 x dome, 2 x bullet & CCTV sticker Kit
LA5336 **WAS $59.95 NOW $49.95 SAVE $10**

With Security Alarm

Can work stand-alone to record audio and video or expanded with sensors (sold separately) to turn it into a security system.
QC3870 **JUST $129**
ALSO AVAILABLE:

Wireless Panic Button	QC3872	**$19.95**
Wireless Reed Sensor	QC3874	**$19.95**
Wireless PIR	QC3876	**$29.95**

amazon alexa ENABLED

Wi-Fi NEW

NOW $199

Wi-Fi

SAVE $50

Wi-Fi RFID access keypad

Control doors remotely with your Smartphone via free app. Used as a standalone access card reader or controlled by an external access controller. Includes a timer function allowing people to access for a temporary period of a time.
- 12VDC
- IP65 rated
- 83(W) x 125(H) x 22(D)mm

LA5358 **WAS $249**

Don't forget your door strike!
LA5077 **$44.95**

100 ZONES

Wi-Fi

JUST $299

Wi-Fi alarm system with smartphone control

Control it via touchscreen, wireless key fob remote or your Smartphone over your wireless network. Features SMS, email or auto-dial feature. Kit includes motion sensor, 2 x door/window sensors, key fob remote, batteries and power supply. See website for more details.
LA5610

ADDITIONAL ACCESSORIES AVAILABLE:

Door/Window Switch	LA5616	**$29.95**
Key Fob Remote	LA5618	**$29.95**
Motion Sensor	LA5614	**$39.95**
Bell Box Siren	LA5619	**$99.95**

30% off accessories*
*Accessories listed as advertised. Valid with purchase of LA5610.

what's new

CONCORD

4K UHD

JUST
$299

NEW

50m HDMI fibre optic cable
Uses both fibre optic and copper cores to transmit Ultra HD 4K signals. Supports up to 6Gbps per channel (18Gbps total). Lightweight, flexible, with ultra-small fixed installation bending radius of 20mm.
WQ7496

Not long enough?
100m long (WQ7498) available for special order only. See in-store or online for details.

CONCORD

4K UHD

JUST
$129

NEW

4-Way 4K HDMI switcher
Switch to 4 different HDMI displays.
- Up to 4K x 2K video resolution
- High-Dynamic-Range (HDR) video support
- 3.5mm stereo audio output socket

AC5010

CONCORD

4K UHD

FROM
$89.95

NEW

4K HDMI splitters
Connects a single HDMI source to up to four HDMI displays.
- Up to 4K x 2K video resolution
- High-Dynamic-Range (HDR) video support
- HDCP, 3D & CEC Bypass

2-Way AC5000 **$89.95**
4-Way AC5002 **$139**

NEW

JUST
$49.95

Bluetooth
WORKS WITH PHONES & TABLETS

Multi-device Bluetooth® keyboard
Compact 78 key Qwerty layout with quiet-key action.
- Lightweight waterproof design
- Slim 18mm height

XC5138
ALSO AVAILABLE:
Wireless USB Keyboard and Mouse XC5136 **$29.95**

NEW

JUST
$49.95

VGA to composite & s-video converter
Converts a VGA output to standard RCA composite video, VGA and S-Video outputs simultaneously.
- Simultaneous PC & TV display
- USB powered

XC4907

FROM
$14.95

NEW

Optical mouse
Ergonomically designed.
Wired XM5245 **$14.95**
Wireless 1600DPI XM5247 **$19.95**
Bluetooth® 1600DPI XM5249 **$29.95**

essentials to complete your alarm system

NOW
$42.95

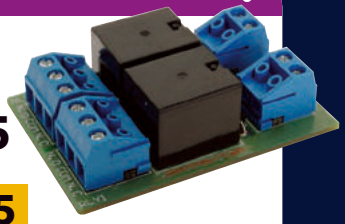
SAVE $7

4P/6P/8P/10P crimp tool
Cut, strip, and crimp flat telephone cable, or CAT5E type cable. Carbon steel.
TH1936 **WAS $49.95**

FROM
$14.95

SAVE UP TO $10

Alarm cables
30m. Sold per roll.
4-Core WB1591
WAS $21.95 NOW $14.95 SAVE $7
6-Core ACA Approved. WB1596
WAS $44.95 NOW $34.95 SAVE $10



NOW
$19.95

SAVE $5

Alarm relay module
Supply an external power source so as not to overload the power supply and switch high currents to multiple sirens and strobe lights in large alarm installations.
- 15A current
- NO and NC contacts

LA5558 **WAS $24.95**

JUST
$4.95 ea.

2.1mm DC connectors
Comes with screw terminals.
Plug PA3711
Socket PA3713

JUST
$5.95

Security alarm reed switch - double throw
You have both types of contacts on the one unit. Normally Open (N.O.) and Normally Closed (N.C.) per pair. LA5070

JUST
$9.95

Indoor piezo alarm
Popular for indoor use with house alarm. Dustproof and waterproof. 100dB output.
LA5256

Alarm & NBN system backup battery
Avoid being left unsecure or without internet & comms in case of power outage. Check and replace at regular intervals. 12V 7.2Ah. SB2486

JUST
$34.95

NOW
$14.95 ea

SAVE $5

LED strobes
For security, alarm or emergency use. Low current consumption. Fully sealed and waterproof. 12VDC operation.
- Blue, red and amber available
- 70(Dia) x 45(H)mm

LA5326-LA5328 **WAS $19.95ea.**

NOW
$19.95

SAVE $5

Plastic siren cover
RUSTPROOF! Accepts 5" siren, has 3 holes drilled for mounting strobe and bracket for mounting a tamper switch.
LA5112 **WAS $24.95**

PROJECT:
IoT button notifier

Have you ever needed someone around the home or office to alert you because you are too busy or far too engrossed in your source code to hear the doorbell ring? This project combines an ESP8266 and an LCD screen to make a nice little two-way notifier with LED button. Once the button of the unit is triggered, it will send notification to your computer through Wi-Fi connection and you can send a message back. No bells or whistles, just a simple button that could perform a simple task.

SKILL LEVEL: Beginner
TOOLS: Soldering iron, drill, hot glue gun

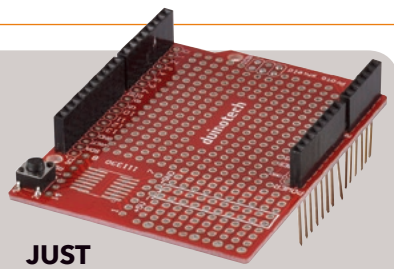
SEE STEP-BY-STEP INSTRUCTIONS AT:
www.jaycar.com.au/iot-button-notifier

Wi-Fi Mini ESP8266 Main Board	XC3802	**$24.95**
Dot Matrix LCD 16x2 Character	QP5521	**$19.95**
IP65 Enclosure with Mounting Flange 115(W) x 65(D) x 40(H)mm	HB6213	**$12.95**
DPDT Illuminated Momentary IP65 Switch Red	SP0741	**$11.95**
I2C Port Expander Module for LCD	XC3706	**$9.95**
Prototyping Shield for Wi-Fi Mini	XC3850	**$4.95**
2.1mm Male DC Power Connector	PS0522	**$2.95**
9.1k Ohm 0.5W Metal Film Resistors - Pk8	RR0595	**55¢**
BC547 NPN Transistor	ZT2152	**30¢**

NERD PERKS BUNDLE DEAL
$49.95
SAVE 40%
KIT VALUED AT $88.50

maker essentials

Prototyping board shield



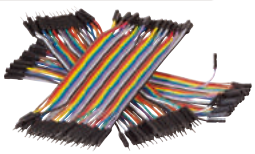
This stackable shield makes semi-permanent prototyping simple.
- Includes reset button
- SOIC-14 breakout, for surface mount ICs
- 68(L) x 53(W) x 12(H)mm

XC4482

JUST $15.95

NOW $29.95
SAVE $14

Breadboard - 1660 tie points
400 distribution holes / 1280 terminal holes. Mounted on a metal plate. 3 banana terminals. Rubber feet. 157(W) x 237(H)mm.
PB8816 **WAS $43.95**



JUST $14.95

Jumper lead mixed pack - 100pce
A mixed pack of jumper leads for your Arduino®, breadboarding and prototyping projects.
WC6027

FROM $6.95

Jumper test lead kits
Ideal for connecting devices for testing. 10 leads supplied.
Standard WC6010 **$6.95**
Heavy Duty WC6020 **$11.95**

JUST $9.95

Mixed hook and loop cable ties
Keep your cables neat and tidy.
- Assorted sizes from 125 to 180mm
- Pack of 16

HP1232

FROM $4.50

PC boards - vero type strip
Alphanumeric grid, pre-drilled 0.9mm, 2.5mm spacing.
95 x 75mm
HP9540 **$4.50**
95 x 152mm
HP9542 **$7.95**
95mm x 305mm
HP9544 **$11.50**

JUST $8.95

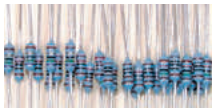
Spot face cutter for strip boards
Designed to neatly remove copper track on strip type prototyping boards.
- 110mm long

TD2461
Strip board not included.

NOW $19.95
SAVE $10

Assorted LED pack
- Contains 3mm and 5mm mixed colours
- Includes 10 x 5mm mounting hardware
- 100-pieces

ZD1694 **WAS $29.95**
See website for full contents.



NOW $12.95
SAVE $4

0.5W 1% Mini size metal film resistor pack
- Contains 5 of each value from 10Ω to 1MΩ.
- 300-pieces

RR0680 **WAS $16.95**
See website for full contents.

NOW $9.95
SAVE $3.55

Electrolytic capacitors pack
- Ideal for prototyping
- Values range from 1µF to 470µF
- 55-pieces

RE6250 **WAS $13.50**

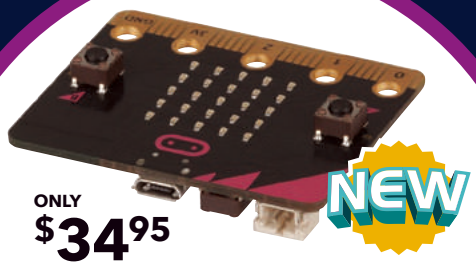
your destination for

the latest maker technology

We love to help you make things! Get started, or add to your collection of Arduino® and Raspberry Pi compatible hardware, and build something new!

ARDUINO® COMPATIBLE
This icon indicates that the product will work in your Arduino® based project.

RASPBERRY PI COMPATIBLE
This icon indicates that the product will work in your Raspberry Pi project.

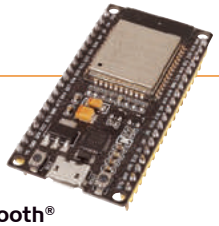


ONLY
$34.95

micro:bit go development board bundle

Pocket-sized computer that you can code, customise and control to bring your digital ideas, games and apps to life. Completely programmable via Microsoft MakeCode or MicroPython. Includes cable and battery pack.
- Bluetooth® connectivity
- 5 x 5 LED display

XC4320



JUST
$39.95

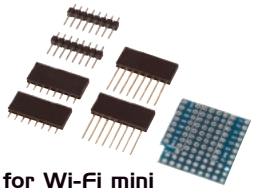
ESP32 main board with Wi-Fi and Bluetooth®

Powerful dual core microcontroller equipped with Wi-Fi and Bluetooth® connectivity. 512kB of RAM, 4MB of flash memory and heaps of IO pins.
XC3800

JUST
$24.95

Wi-fi mini ESP8266 main board

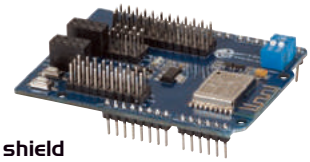
Perfect compact solution to your IoT sensor node problem. Packs an 80MHz microcontroller with Wi-Fi into a board. 4MB flash memory. 11 digital IO pins.
XC3802



JUST
$4.95

Prototyping shield for Wi-Fi mini

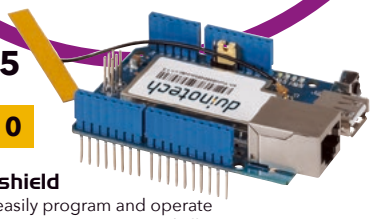
Create custom hardware and add features to your project or build custom sensor nodes or output modules.
XC3850



JUST
$39.95

ESP-13 Wi-Fi shield

Uses the powerful ESP8266 IC and has an 80MHz processor. An excellent way to get into the IoT. Integrated TCP/IP stack. Simple AT command interface with Arduino® main board.
XC4614

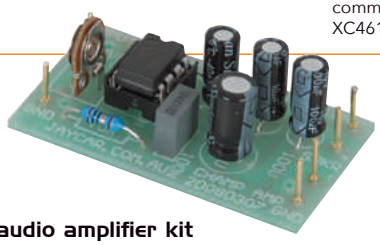


NOW
$59.95

SAVE $10

Yun Wi-Fi shield

Allows you to easily program and operate your Arduino® project over Wi-Fi and allow it to access the Internet. Contains a tiny Linux computer with Wi-Fi, ethernet & USB. XC4388
WAS $69.95



JUST
$9.95

"The champ" audio amplifier kit

This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9V supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9V battery, allowing it to fit into the tightest of spaces. PCB and electronic components included.
- 46(L) x 26(W)mm

KC5152

kit back catalogue

We maintain in our central distribution warehouse an extensive range of discontinued Electronic Project Kits. Place your order online for the Kit Back Catalogue. On our website each of these kits has a full description and, where available, a link to the original article on the Kit.
www.jaycar.com.au/kitbackcatalogue

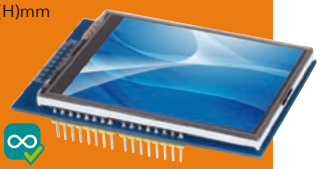
microcontroller displays

JUST
$19.95

128 X 128 LCD screen module

Compact, supporting 16 bit colour display.
- SPI interface
- 43(L) x 30(W) x 12(H)mm

XC4629



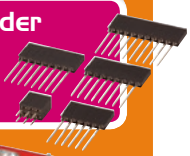
JUST
$29.95

240 X 320 LCD touch screen

Large, colourful touch display shield which piggy-backs straight onto your UNO or MEGA. Fast parallel interface. microSD card slot.
- Resistive touch interface
- 77(L) x 52(W) x 19(H)mm

XC4630

Free stackable header
HM3208 **Valued at $4.50**
Valid with purchase of XC4629, XC4630 or XC4384



JUST
$29.95

128 X 64 OLED display module

Monochrome graphics with wide viewing angle and I²C interface. SSD1306 Chipset
- 22(L) x 22(W) x 12(H)mm

XC4384

JUST
$64.95

Android Apps

Explains the operation of the Android® OS in a clear step-by-step method. Covers simple math programs to programming for advanced Internet applications.
- Soft cover, 244 pages

BT1382

JUST
$59.95 NEW

Python 3 programming and GUIs 2nd edition

Aimed for engineers, scientists and hobbyists who want to interface PCs with hardware projects using graphic user interfaces.
Covers both desktop and web based applications.
- Soft cover, 222 pages BT1381

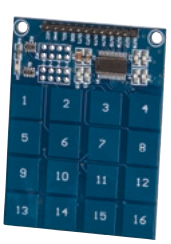
ALSO AVAILABLE: 1st Edition. BT1380 **$59.95**

JUST
$19.95

Touch shield for Arduino®

- 9 capacitive touch pads
- Up to 12 touch sensitive buttons
- On-board logic level converter allows it to work with 5V and 3.3V Arduino® boards

XC4551



JUST
$9.95

16 Key touch keypad module

- Compact 16 key touch interface for your Arduino® compatible project
- Works on 2.4-5.5V
- Onboard power indicator
- Two wire serial data interface

XC4602

nerd perks

Love Jaycar?

You're going to love our rewards

Sign up now!

Shop
In store & online

Earn Points
For dollars spent
1 point = $1

Get Rewards
eCoupons for future shops in store
200 points = $10 eCoupon

+ Perks
offers
event invitations
account profile
and more...

nerd perks half price deal!

NERD PERKS
$29.95
SAVE $30

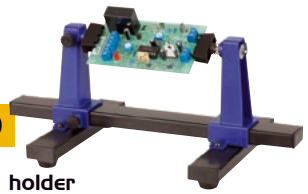
48W temp' controlled soldering station
Lightweight with anti-slip grip. 150°C to 450°C.
TS1620 **REG $59.95**

NERD PERKS
$24.95
SAVE $25

50W 240VAC to 115VAC stepdown transformer
Includes overheat protection. 2 pin US socket.
MF1091 **REG $49.95**

NERD PERKS
$44.95
SAVE $45

VGA to HDMI converter & upscaler
Plug and play. AC1718 **REG $89.95**



NERD PERKS
$9.95
SAVE $10

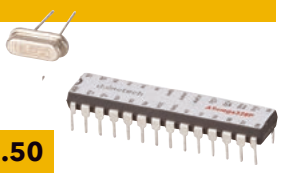
Desktop pcb holder
Hold PCBs of up to 200 x 140mm.
PCB not included. TH1980 **REG $19.95**

NERD PERKS
$7.45
SAVE $7.50

FM radio snap-on kit
Ages 7+. Requires 2 x AA batteries. KJ8978
REG $14.95

NERD PERKS
$7.45
SAVE $7.50

4-in-1 magnetic charging hub
Includes 30 pin iPhone® connector, Mini USB, Micro-B USB and Nokia connector.
MB3651 **REG $14.95**
Smartphone not included.



NERD PERKS
$6.45
SAVE $6.50

ATMEGA328P MCU IC
Comes with the Arduino® Uno bootloader and 16MHz crystal ZZ8727 **REG $12.95**

NERD PERKS
$19.95
SAVE $20

Hex ratchet crimping tool
Crimp F, N, BNC, TNC, UHF, ST, SC & SMA connectors onto RG6 or RG58 coax cable.
TH1833 **REG $39.95**

NERD PERKS FROM
$14.95
SAVE UP TO $20

APV series LED drivers
Indoor use. 300mm long lead. 12W & 16W available. MP3371-MP3373
RRP FROM $29.95-$39.95

Exciting launch April 1st

nerd perks in DIGITAL# rewards faster + new perks!

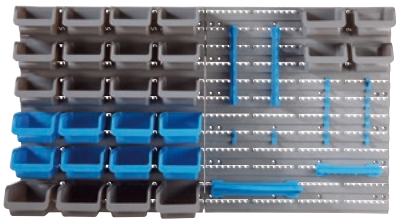
See website for details + new T&Cs April 1st

#Card free club with eCoupon rewards: we've phased out cards but member cards & Jaycoins cards can still be used until expired. Is your email up to date? Check in store or online now.

your destination for

workbench essentials

FROM
$29.95
SAVE $10



Storage organisers

Keep your workbench neat and tidy!
Provides various methods for storage.
- Assorted bin sizes

44 Piece Blue & Grey HB6340 **WAS $39.95 NOW $29.95 SAVE $10**
16 Bin Red & Blue HB6341 **WAS $49.95 NOW $39.95 SAVE $10**

NOW
$24.95
SAVE $15

Bench vice

- Made from hard-wearing diecast aluminium
- Vacuum base and ball joint clamp
- 75mm opening jaw
- 160mm tall (approx)

TH1766 **WAS $39.95**

FROM
$13.95

Digital vernier calipers

- 5-digit LCD
- 0-150mm (0-6") range
- Batteries included

Budget
TD2081 **$13.95**
Professional Stainless Steel
TD2082 **$39.95**

Anti-static essentials

BUNDLE DEAL
$49.90
SAVE 35%
VALUED AT $76.80

Conductive Brush	TH1775	**$9.95**
Anti-static Strap	TH1780	**$13.95**
ESD Safe Tweezer Set	TH1760	**$19.95**
ESD Safe Sidecutters	TH1922	**$32.95**

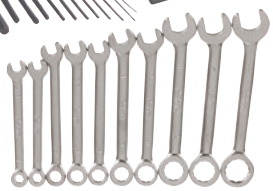
Jaycar offer a complete line of static control products for virtually any situation

Allen key set

25 different sizes (both metric and imperial) in a plastic wallet.
TD2052
WAS $11.95

NOW
$9.95
SAVE $2

NOW
$19.95
SAVE $5



Spanner set

Set of 10, open end/ring combination. Suitable for light hobbyist use. Supplied in a plastic wallet.
TH1910 **WAS $24.95**

We offer a wide range of soldering irons suitable for you. See full range in-store or online.

JUST
$19.95

6W battery powered

- Long-life tip with protective cap
- 3 x AA batteries required

TS1535

JUST
$14.95

8W USB powered

- Long-life tip with protective cap
- 2-in-1 Heating element and soldering tip
- Automatic shut-off

TS1532

JUST
$19.95

30W 12V powered

- Fused cigarette lighter plug lead to power from your car cigarette lighter socket
- Metal sheet solder stand included

TS1536

JUST
$13.95

25W mains powered

- Stainless steel barrel
- Orange grip impact resistant handle
- Fully electrically safety approved

TS1465

1. Anti-static field service mat/bag

- Ideal for field service people
- Mat folds out to work area of 600 x 600mm (approx)
- 2 pouches at one end
- Ground lead and wrist strap included

TH1776 **WAS $39.95**

2. 32-piece precision driver set

- High quality
- Ideal for jewellery, model making or electronics
- Storage case included.

TD2106

3. Solder fume extractor

- Designed to remove dangerous solder fumes from the work area
- Suitable for use in production lines, service centres, R&D workbenches or the hobbyist

TS1580 **WAS $69.95**

4. 60W soldering station with LED display

- Vented soldering iron stand with integrated sponge and tray
- Celsius or Fahrenheit temperature display
- 60W heating element
- 160-480°C temperature range

TS1640 **WAS $149**

5. LED illuminated clamp mount magnifier

- Powerful 125mm diameter 3 dioptre lens
- High / low light setting
- Fully adjustable arm with clamp mount
- Large diameter magnifier
- Interchangeable lens option

QM3554 **WAS $119**

6. True RMS autorange multimeter

- Technician multimeter
- CATIII. 1000VDC, 750VAC
- Up to 10A

QM1321

Free delivery on online orders over $70
Conditions apply - see website for details.

clearance

save up to $80

NOW
$199

SAVE $80

2.4GHz Wireless 1080p
HDMI AV Sender & receiver
Full HD 1080p. Plug and play with most digital pay TV or home theatre systems, providing an amazing clarity at up to 15m line of sight. Includes infrared emitter, infrared receiver and two mains power adaptors. AR1905 **ORRP $279**

NOW
$249

SAVE $50

Inspection camera with detachable wireless screen
Capture video and pictures in confined and dark locations. 3.5" detachable LCD screen gives more flexibility during operation. IP67 rated camera and 1m flexible boom. 2GB microSD card included.
QC8712 **WAS $299**

NOW
$149

SAVE $50

LED Projector with HDMI & USB
Robust LED design. Projection distance up to 3m. 120" viewable size. HDMI, Composite, VGA or SD card inputs. Remote control included. AP4003 **ORRP $199**

all half price!

NOW
$9.95

HALF PRICE

Car battery monitor
Get an instant LED readout of your cars battery voltage. Works on 12/24V vehicles.
QP2220 **WAS $19.95**

NOW
$27.45

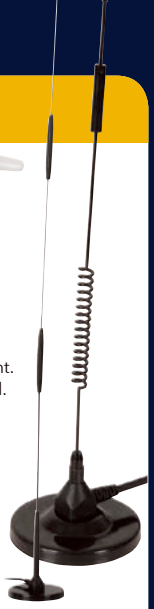
HALF PRICE

Alcohol breath tester
Easily check your blood alcohol content. Backlit LCD. 3 x AAA batteries required.
QM7304 **WAS $54.95**

Wireless networking antennas
Connect these 3G/4G antennas with FME connector to your 3G/4G wireless modem to speed up wireless Internet and boost reception.

5dBi 290mm Long
AR3310 **WAS $49.95 NOW $24.95 SAVE $25**

7dBi 950mm Long
AR3312 **WAS $69.95 NOW $34.95 SAVE $35**



FROM
$24.95

HALF PRICE

NOW
$69.95

SAVE $20

HDMI Audio extractor
Extracts high quality audio in digital optical, digital coaxial or analogue 3.5mm stereo audio. Suitable up to 4k2k @ 60Hz. AC1739 **WAS $89.95**

NOW
$49.95

SAVE $20

10,000Mah dual usb power bank With quick charge™
Huge 10,000mAh Li-Po battery supports powering and recharging your devices. Recharge the unit via USB Type-C or micro USB.
MB3725 **WAS $69.95**

NOW
$29.95 ea

SAVE $20

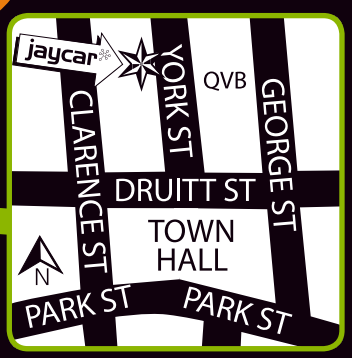
2-Way displayport AC1755
SPLITTER Send identical signals to two monitors simultaneously.
AC1755 **WAS $49.95**
SWITCHER Select between two signal sources to send to a single monitor.
AC1757 **WAS $49.95**

NOW
$11.95

SAVE $8

Fast lithium battery charger with USB outlet
Suitable for Li-ion, LiFePo4, Ego, Ni-MH and Ni-Cd batteries.
MB3700 **ORRP $19.95**

TERMS AND CONDITIONS: RREWARDS / NERD PERKS CARD HOLDERS FREE GIFT, % SAVING DEALS, DOUBLE POINTS & MEMBERS OFFERS requires ACTIVE Jaycar Rewards / Nerd Perks Card membership at time of purchase. Refer to website for Rewards/ Nerd Perks Card T&Cs. PAGE 2: 30% OFF Alarm accessories applies to LA5616, LA5618, LA5614 & LA5619 with purchase of LA5610. PAGE 4: NERD PERKS DEAL: IoT Button Notifier for $49.95 when purchased as bundle (1 x XC3802 + 1 x QP5521 + 1 x HB6213 + 1 x SP0741 + 1 x XC3706 + 1 x XC3850 + 1 x PS0522, 1 x ZT2152 & 1 x RR0595). PAGE 5: FREE Stackable Header (HM3208) valid with purchase of XC4629, XC4630 or XC4384. PAGE 7: Anti-static Bundle for $49.90 when purchased as a bundle (1 x TH1760, 1 x TH1775, 1 x TH1780 & 1 x TH1922).



Sydney City
127 York St Sydney (Opposite QVB)
NSW 2000
PH: 02 9267 1614

For your nearest store & opening hours:

1800 022 888
www.jaycar.com.au

100 stores & over
140 stockists nationwide

jaycar

Head Office
320 Victoria Road,
Rydalmere NSW 2116
Ph: (02) 8832 3100
Fax: (02) 8832 3169

Online Orders
www.jaycar.com.au
techstore@jaycar.com.au

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock. Savings off Original RRP. Prices and special offers are valid from catalogue sale 24.3.19 - 23.4.19.

SERVICEMAN'S LOG

A laptop, spilled tea and a crack

Dave Thompson

The vast majority of my 'bread-and-butter' work is mundane to the point of being drop-dead boring. Most of it wouldn't even pass muster as a footnote to more interesting stories. If I wrote a column solely about these jobs, you'd probably unsubscribe in disgust. However, occasionally a job will come along that is worth mentioning.

Items Covered This Month

- Repairing a beaten laptop
- Cleaning PC motherboards
- Philips air fryer repair

Dave Thompson runs PC Anytime in Christchurch, NZ.

Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

One such job that comes to mind is something I tackled a little while ago. A customer brought in a laptop that wouldn't boot.

It had been working well until recently; I'd given it a thorough service about six months ago. But while cleaning a shelf above the computer desk, the owner had dislodged a decorative, over-sized tea mug and this had fallen onto the laptop, landing square in the middle of the keyboard.

The machine wasn't running at the time, but when she tried to power it up after the event, the lights were on but nobody was home. She called and asked for advice, and my recommendation was that she bring it in so I could assess it, see what's going on and then we could go from there.

It seems to be the way things often work out that the customer was in the middle of an assignment that was due in a few weeks and her main concern was losing her data. I told her on the phone that while it was very likely her data was intact, I wouldn't know for sure until I got my hands on the machine.

The fact the laptop wasn't running at the time, and the likelihood of the hard disk being mounted some distance away from ground zero, meant that it would probably be OK.

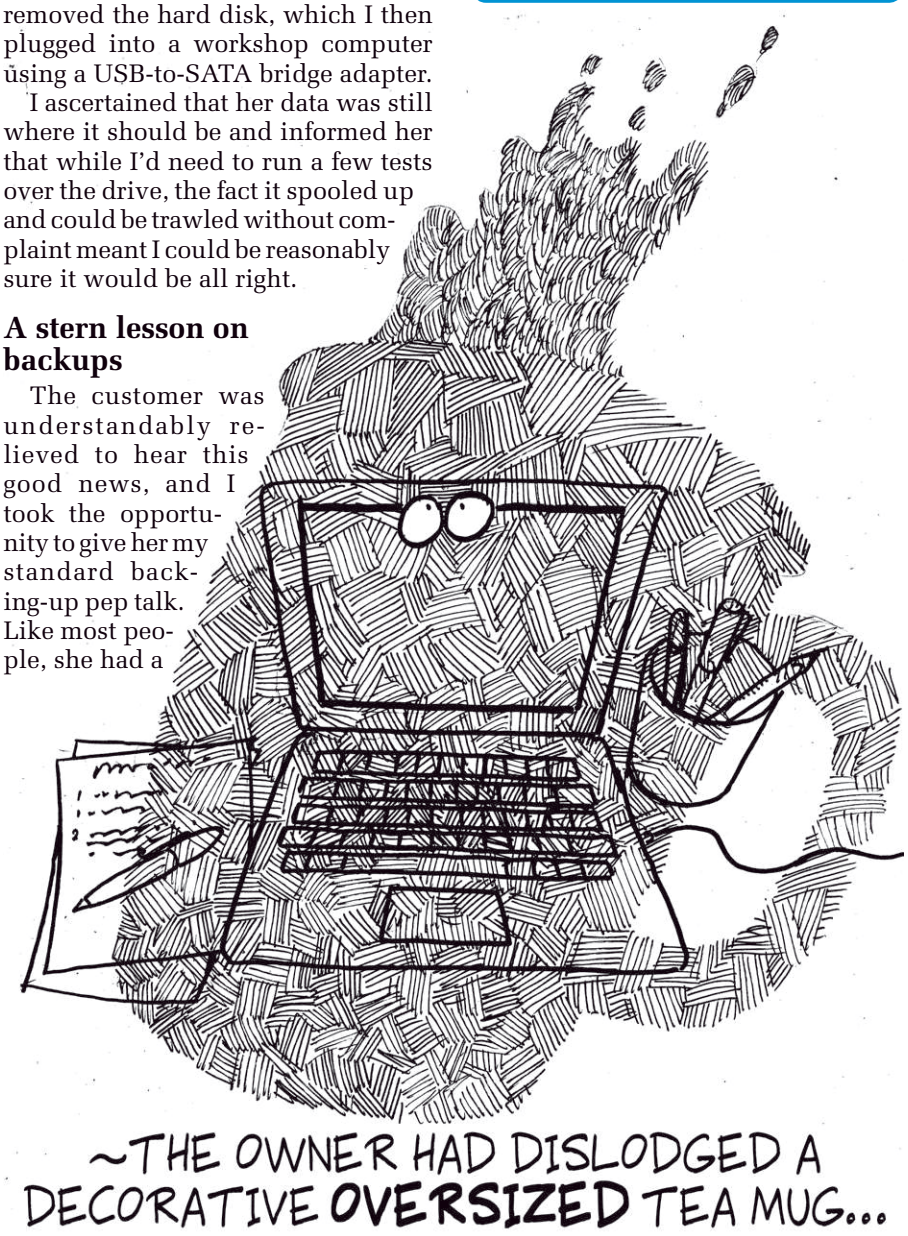
When I opened the lid, the first thing I noticed was a slight bulge in the centre of the keyboard, which she confirmed was the area of impact. While barely perceptible, it was readily apparent in the right light. That sort of thing never bodes well, given the lack of room available in most laptops; something must have given way under there.

I whipped the back plate off and removed the hard disk, which I then plugged into a workshop computer using a USB-to-SATA bridge adapter.

I ascertained that her data was still where it should be and informed her that while I'd need to run a few tests over the drive, the fact it spooled up and could be trawled without complaint meant I could be reasonably sure it would be all right.

A stern lesson on backups

The customer was understandably relieved to hear this good news, and I took the opportunity to give her my standard backing-up pep talk. Like most people, she had a



backup system installed and set up, but after the first initial backups done many months ago, she just never got around to running it again.

Given that people's data can change radically within days, a regular backup is never a waste of time. While a lot of today's technology users rely on the "cloud" retaining backups of all their data, many have no idea where that data actually is or even how to go about retrieving it should disaster strike.

They've either been told that once they set up their phone or computer that all their data will automatically be backed up to a cloud account, or they've misunderstood what backing up to the cloud really entails.

Easily-overlooked details such as needing to have an active iCloud, OneDrive, Google Drive or similar account in place and the fact there is often a need to actively manage the files that are supposed to be backed up to remote locations leaves users vulnerable to data loss.

It is also worth remembering that in the past, services such as Google, Amazon and Yahoo have lost vast swathes of users' data with no recovery or compensation. Users with years of email history, documents, photos and other irreplaceable files had to write it all off and start over from scratch.

That's a tough pill for anyone to swallow, yet these sites offer precious little information on how to go about backing up that cloud data, requiring end users to deal with it instead.

Editor's note: if you use Google services and are concerned about this, check out ***http://takeout.google.com*** *which allows you to download most of your data hosted by Google, easily.*

I'm not saying don't use such services – I make good use of the OneDrive system that comes with later versions of Windows. I'm just saying that these companies typically encourage end-users to forgo local data storage and hard-copies in favour of using their all-singing/all-dancing online services. Many users aren't even aware that these services can fail, so it is essential that backups are made and kept up-to-date.

If that isn't bad enough, many new customers of mine are horrified to discover they are not backing up what they thought they were backing up. I've seen plenty of external drive 'backups' with only desktop icons, empty folders or thumbnail files instead of original photos copied over.

I try to remedy these situations by installing and setting up a backup program that takes just three mouse-clicks to get up and running.

However, while it can be scheduled to run automatically, there is usually still some manual input required, such as plugging in an external hard drive or flash drive on which to copy the backed-up data, and people being people, this is the point we usually forget or simply flag it, convincing ourselves it'll be OK for one more day.

If only I had a dollar for every time I heard that mentioned after a hard disk failure!

We now resume our regular service(man)

Back to the bulging laptop. I removed the screws holding the keyboard in place (typically hidden under panels around the back of the machine) and carefully released the retaining clips to prise the keyboard out. Surprisingly, no keys had broken or popped off, something that often happens when a heavy object is dropped on a laptop keyboard.

Repairing those little cantilever plastic 'springs' under the keys is a royal pain, so thank goodness for small mercies.

Underneath, I could see areas of the motherboard and the usual peripheral-connecting ribbons poking through open sections in the top frame. I could also see where the cup had impacted; there was a nice dent in the thin metal chassis. Beside that was a multi-pin plug that had popped off its socket; the plug's leads disappeared off to the screen, so this explained the lack of video. It also explained the keyboard hump.

This could be an easier fix than I thought; all I had to do was panel-beat the bent section of the case back into its original shape, plug that big connector back in and it should work.

But you know it's never going to be that easy! When I tried to replace the popped plug, it wouldn't re-seat, and on closer inspection, I could see that the socket mounted on the motherboard was cracked right through, making each end kinked slightly off-line and preventing the plug from going in. Excellent! Of all the places on this motherboard, the cup had to fall onto this point.

Before going any further, I had to remove everything from the case so that I could straighten the bent chassis properly, and that entailed taking out the motherboard assembly.

There was nothing special to it, just a lot of screwdriver time making sure all the screws were removed (even the one hidden under the hard disk and the three tiny ones along the edge hidden by the CD-ROM drive) before separating the clips holding the two halves of the case. I soon had the case bent back into shape, but I was more concerned about this 40-odd pin micro-socket with the crack in it.

Getting to the root cause

The connector is similar to a PCB stacking connector, and a quick browse on the usual-suspects component sites revealed that they are available for only about five bucks.

The problem is that while I could probably fluff about and fluke soldering one of these things on, getting the old one off without a lot of collateral damage would be a real mission.

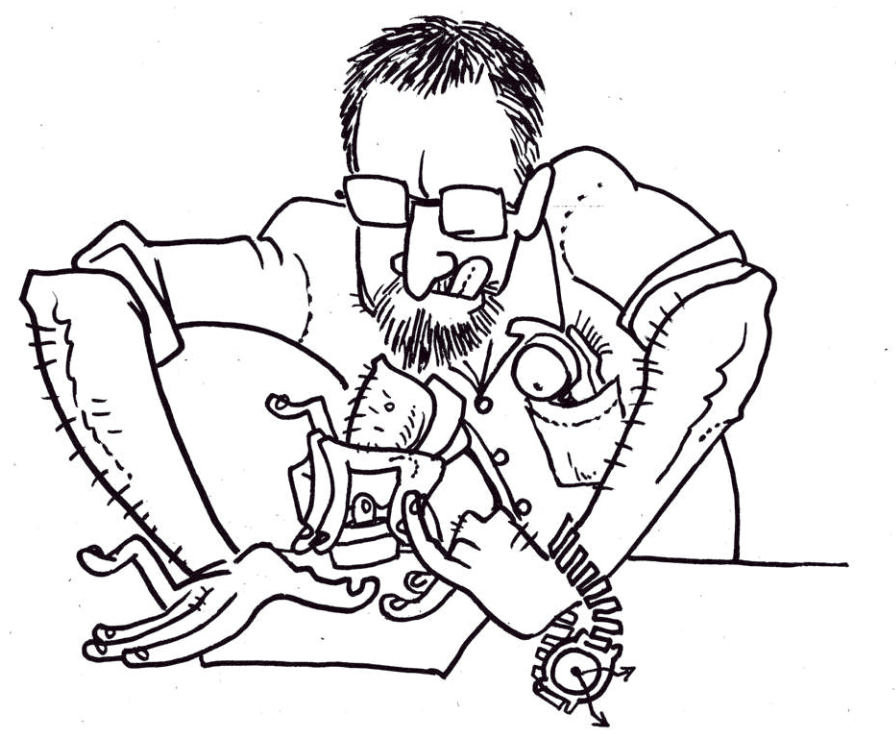
I know this because I have attempted

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.



stuff like this in the past, and at the risk of being labelled a man who blames his tools, I blame my lack of proper SMD desoldering tools – and the talent to make the best use of the ones I do have. If this was my motherboard, I'd likely have a go, but for a paying customer, I draw the line.

Removing an 8-pin SMD is one thing, taking off a bonded 40-pin socket like this is another game entirely, especially when it is on a tightly-packed motherboard.

So I thought I'd check it under a microscope before deciding what to do next. I could see that all the legs were still securely soldered and nothing was really out of place, except for the misalignment of the now-separated hard resin body of the socket.

The crack went right through it, and if I pressed in the right places using some repurposed dental tools, I could close the crack right up and straighten the socket, likely enough to put the plug back onto it. But as soon as I released the pressure on it, it would open up again.

I made a vague attempt to close the socket and while holding it closed, replace the plug with my third hand, but while it did close with a bit of pressure, it wouldn't hold, and without some extra tweaking I knew this wasn't going to fly.

Back under the microscope, I could see the majority of the socket's pins were still straight, with only a couple on each side adjacent to the crack itself bent out of line.

All the pins were holding the two halves of the socket tightly, if apart. I reckoned that if I could straighten those bent pins, this would relieve the stress holding the break open, and it would let me get some glue in there to close the crack.

I would then just need to hold it long enough for the glue to cure, and in theory, I would be able to re-connect the plug and it "should" work. That's a whole lot of "ifs" though…

The biggest problem I faced is that one drop of glue in the wrong place and I'd be right in the litter box; the connector would never go back onto the socket and if it did, the chances are that one or more pins wouldn't make proper contact.

Considering the size of the component, and the consistency of most of the glues I have access to that could bond this type of resin with any strength, I would have trouble getting enough glue into the crack without spilling any over into the surrounding areas. I would also only get one shot with this method and if it didn't work, it would be game over.

After much wringing of hands and gnashing of teeth, I considered my only feasible option would be to juggle things enough so I could dry-fit the plug to the socket, make sure it

worked and then spread glue over the entire plug and socket assembly so it couldn't move.

With this method, the elephant in the workshop is the trouble I would be in if it ever became necessary to get it apart again, ie, if something else should go wrong with the laptop.

Once the plug was potted, it wouldn't be coming off again and, due to the way the connected cable interacts with other removable parts of the laptop, that would make disassembling the machine again virtually impossible.

I decided to put these issues to the client, who had already been half-resigned to getting a new machine anyway, given she thought this one was dead.

I called her and told her what I'd found, and after discussing the options, she was happy for me to go ahead and try to repair this one, with the full knowledge that it might not work anyway, and even if it did our future repair options would be severely compromised.

Repair time!

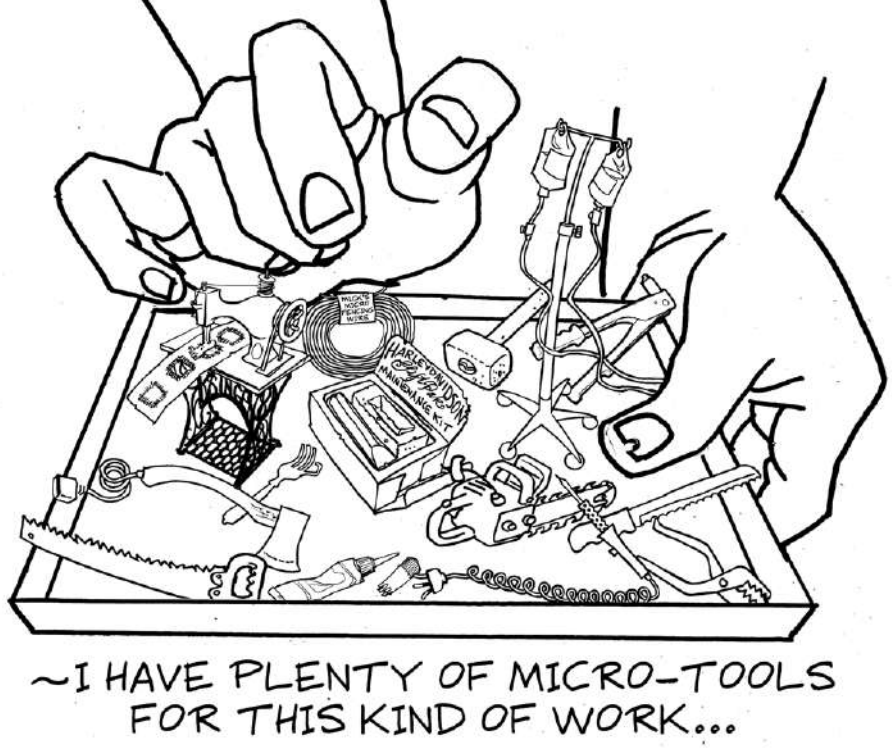
With the go-ahead given, the first thing I did was straighten the pins out. While I have plenty of micro-tools for this kind of work, I always gravitate back to using my array of dentists' tools.

These picks, probes, burs and scalers are excellent for electronics work because they are strong, resilient to fluxes and solders and very hard. I use them for everything from mixing glue to cleaning circuit boards.

Don't be afraid to ask your dentist for old ones – they chuck theirs away regularly, usually regardless of condition because they get brittle with repeated sterilisation (among other things) and become a bit dangerous to use. My dentist has a carton of old tools and I never leave empty handed (it is also nice to get something, other than working teeth, for all that money dropped there!).

The tools are usually cleaned in the autoclave before being disposed of anyway, so there are no worries about them being dirty. I had to promise my dentist that I wouldn't use them on my or anyone else's teeth, and surprisingly, that's not a tough promise to keep!

The extremely sharp probes that typically strike fear into the hearts (and mouths) of patients are ideal for this pin-straightening business. I used one to gently coerce the dodgy pins back into line. This worked better than I expected and all the pins were equally-spaced and still well-connected to the motherboard once I'd finished probing.



The crack in the resin part of the socket now looked to be just a hairline and the plug fitted back onto the socket relatively securely. I assembled the laptop parts on the bench and sat the battery onto the motherboard's battery connector.

When I pushed the power button, the screen lit up and the machine tried to boot, but because I had no hard drive in it, I merely got the usual "no system disk" message.

With that working, I removed the battery and other bits and tried the plug again; it was still too easy to disconnect. Usually, it is held quite firmly by friction, but now it wasn't even holding stable with the plug pushed on as firmly as it would go. I taped it down, mixed up some epoxy resin and 'tagged' it with a good-sized blob at each corner.

When set, the plug was held in so it wouldn't come out, yet was accessible enough so that if I needed to remove it again, I could break the glue. I reassembled the laptop, and with everything attached, it booted into the operating system and worked as expected.

The keyboard no longer had the hump, and there was still some wiggle-room should we need to get it apart again. The owner was happy, I was happy this fix would last, and everybody wins. Sometimes it is worth having a go anyway, even if the outcome looks bleak.

Cleaning motherboards

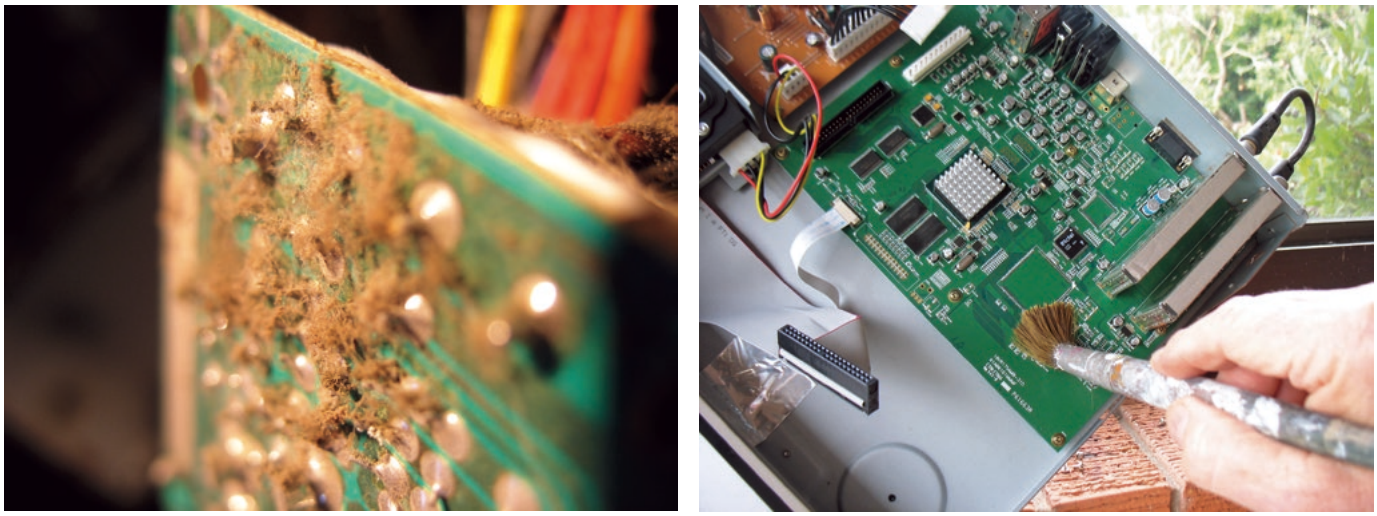
B. W., of Warriewood, NSW lives near the coast, and a common problem with electronics (and especially computers) in these humid areas is corrosion and a build-up of dust and other gunk on the circuit boards.

This eventually interferes with the operation enough to cause failures. The solution is to give them a good old clean and check them over for any other problems while you're at it...

I have five PCs making up a broadcast HD editing system. The oldest, a 2003 model with a Gigabyte motherboard and an 8-slot NAS with 16TB of storage has worked flawlessly for 12+ years, but recently it started getting slower and slower.

Finally, it refused to switch off; then when I forced it off, it wouldn't power back on. While all the power supply output voltages seemed OK, the motherboard lacked 12V in some locations.

It was time to bite the bullet and pull out the motherboard. Living on the coast, many times over the years various bits of electronic gear have chucked a wobbly or just stopped and the reason is usually dust, fluff, hair and other fine debris that gets deposited on the PCBs, stuck down with a salt-laden conductive deposit from the sea breezes we often get.



Before and after cleaning the PC motherboard; note a few of the ICs had not been re-seated yet.

With the narrow pin spacing of modern ICs, the worst thing you could organise is dumping a conductive matting over and between the tracks and the pins of the ICs and surface mount parts.

Many bits of gear are thrown out just because they have been used in this environment for several years and then simply quit working. They usually wind up in the council cleanup.

The simple cure is the get out the methylated spirits, some old toothbrushes, small art painting brushes, clean rags, old newspapers, magnifying glasses, a fine bladed scalpel, and ensure no ignition sources exist.

Pour a small amount of metho into a lid or other container, and use the tools to wash/scrub down the PCB with all the sluiced-off waste going onto the newspaper.

Use the scalpel and toothbrushes to very carefully clear between the fine pins of the ICs. Mop up any leftover metho with a tissue or a rag; you can even use a hair dryer to dry it off, ensuring that no metho hides under the ICs or other components.

Re-assemble the equipment, and that's it. While cleaning up this PC using the above method, I discovered a bloated 3300µF capacitor, so I replaced that too. Then pow, up it came first go, and I'm typing this tale on it.

So before you throw any gear out, give it the big clean; you may be surprised just how well it works, and just how easy it is!

Philips air fryer repair

R. S., of Fig Tree Pocket, Qld has multiple failed power supply boards exhibiting the same fault. He was able to fix them but this raises the possibility that these designs are not rugged enough for our electrical grid...

This problem may be of interest to your readers as it appears to be a common fault with Philips HR2940 Air Fryers. I have two units which were both dead, having no display.

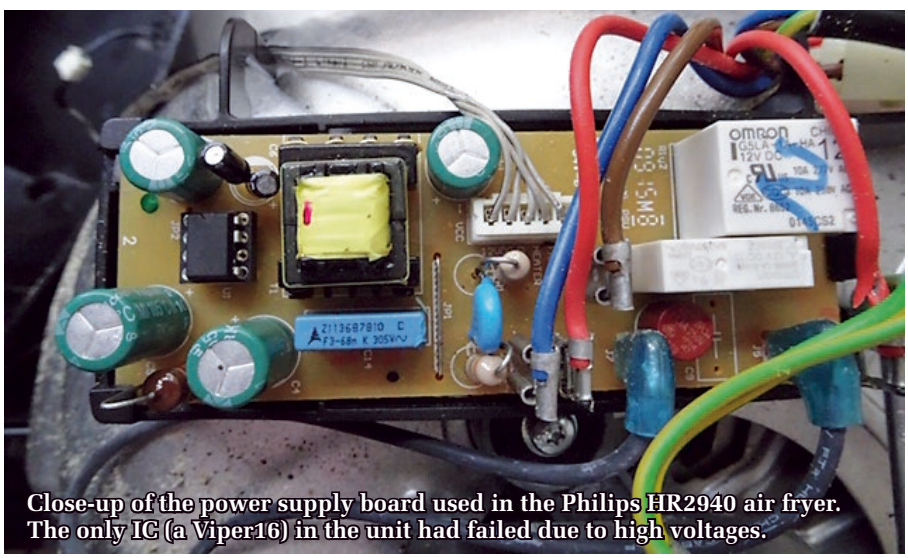
The first problem was removing the top cover to get to the power board. You need a long T20 screwdriver as the screws are deeply recessed. My photo shows the unit after the cover is removed, with the power supply board visible.

The power supply board uses the ST Microelectronics Viper16 8-pin DIP flyback switching regulator IC. This has an internal high voltage (700V) FET which failed and destroyed the two 30Ω resistors feeding it. The fuse survived(!) It seems that these ICs are not able to handle the high voltages they can be exposed to.

Replacement ICs are available from RS components. I also found that C6 (10µF 50 V) was shorted out on both Air Fryer power boards. Replacing the regulators, 30Ω resistors and 10µF capacitors got the units back up and running. Note that the power board will not produce any output unless it is connected to the control/display board.

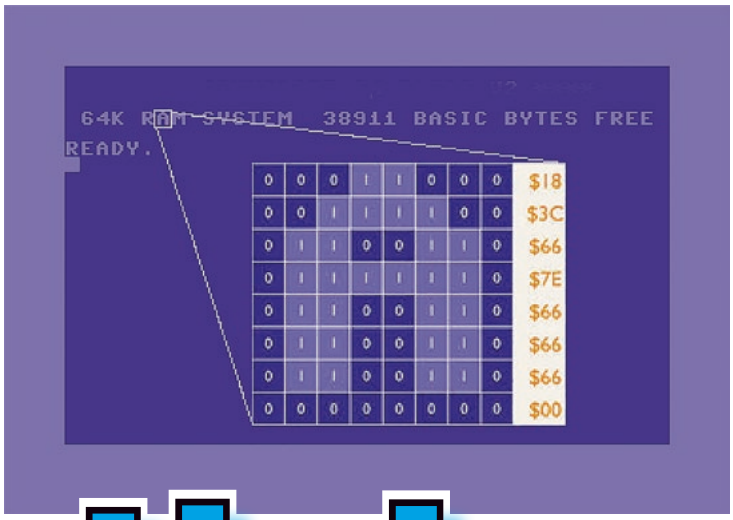
While I had the units open, I also added a metal oxide varistor (MOV; blue disc) across the 30Ω protection resistors at the IC's high voltage inputs. It should reduce voltage spikes getting to the Viper16 IC. I am hoping that this will prevent similar failures in the future.

There is a similar problem with some Toshiba TV power supply boards. These use a similar high voltage 8-pin DIP IC (ICE3B0365) for the 5V standby power supply. These are also made by ST Microelectronics. I have three boards where the same IC has failed. **SC**



Close-up of the power supply board used in the Philips HR2940 air fryer. The only IC (a Viper16) in the unit had failed due to high voltages.

Want to give a project the retro-computer look? Or do you just need a convenient way to display a screen full of text on a low-cost monitor? Then this nifty project is for you! It generates a VGA signal akin to some-thing from an early PC or even a Commodore 64 or Amiga. It does this using a low-cost iCEstick FPGA development board and a very simple add-on board and is controlled via a serial port.



iCEstick VGA TERMINAL

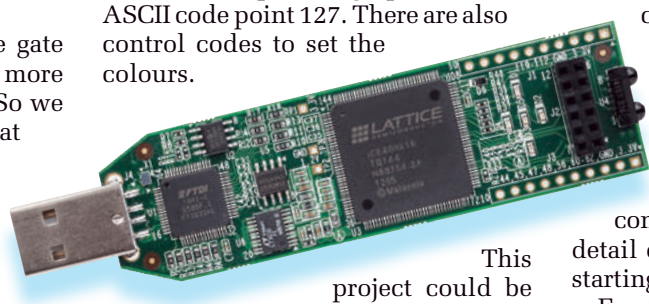
Following on from our review of the iCEstick and IceStudio software (page 32 of this issue), we delved in to see if we could do something more useful and exciting to do than flashing a LED.

After all, field programmable gate arrays (FPGAs) are considerably more capable than microcontrollers. So we had to think of an application that couldn't be done with a 555 timer IC or the most basic micro you can buy!

So we've come up with some 'code' which configures the FPGA chip (an iCE40HX-1k) on the iCEstick to generate VGA-compatible video signals using the eight digital outputs available on its PMOD connector.

The output is displayed as 16 rows and 32 columns of text, with selectable foreground and background colours for each 8x8 pixel character. The colours come from a palette of 16, chosen from 64 possibilities. The graphics ROM includes pseudo-graphics characters to create block graphics, boxes and shaded regions.

The module is controlled by a serial (UART) data line running at 9600 baud which accepts regular ASCII characters, LF, CR and FF control codes, as well as the pseudo-graphics above ASCII code point 127. There are also control codes to set the colours.



This project could be used as the starting point of a more ambitious FPGA-based project, or you could combine it with a microcontroller of your choice, using the serial port as your micro's display interface to the VGA monitor, to display text and graphics.

Note that when it comes to FPGAs, it no longer makes sense to refer to the code as 'software'. The IceStudio software takes our HDL (hardware description language) and synthesises it into a bitstream.

This bitstream could be considered an equivalent to a binary firmware image; it can be stored in a computer file or uploaded to an EEPROM on a target system. But rather than being a sequence of instructions for a processor to execute, it describes how the various elements within the FPGA are connected or configured. For more detail on this aspect, see the tutorial starting on page 32.

For this article, we're providing a complete IDE project which you can open up and use straight away. But it's also a great starting point for experimentation, and a wonderful tool for learning about how FPGAs work (and about digital logic in general).

by Tim Blythman

Circuit description

Most of the hardware required is on the pre-built iCEstick module. A small breakout board that we've designed plugs into the 12-pin PMOD connector, converting the digital signals from

Here's the complete (!) project attached to the iCEstick, which in turn plugs into a free USB socket.

the iCEstick into signals which are fed to the VGA connector, to generate VGA video. The circuit diagram of this add-on board is shown in Fig.1.

The horizontal synchronisation (HSYNC) and vertical synchronisation (VSYNC) lines are effectively fed digital pulses via series resistors, which provide a degree of protection to the FPGA in case of static electricity and so on.

The red, green and blue VGA signals are formed by primitive 2-bit DACs, made using pairs of resistors in a 2:1 ratio, giving four evenly spaced voltage levels between fully off and fully on.

For example, if pins 3 and 9 of CON1 are held low (0V), then 0V is applied to pin 2 of CON2, the green signal. If both these pins are high (3.3V), then pin 2 of CON2 is at 3.3V. If pin 3 of CON1 is high (3.3V) and pin 9 is low (0V) then the voltage divider formed by the 560Ω and 1.1kΩ resistors means that around 2.2V is fed to pin 2 of CON2, while if those voltages are reversed, pin 2 is at around 1.1V.

By using various combinations of levels on the red, green and blue lines, we can generate 4 x 4 x 4 = 64 different colours on the screen.

The 560Ω and 1.1kΩ resistor values have been chosen to avoid exceeding the FPGA's 8mA per pin sink/source current rating. We found that on some monitors, this resulted in colours which were a bit dark, so you may wish to try slightly lower values (eg, 470Ω and 910Ω or 430Ω and 820Ω). If you are unsure, stick with the suggested values.

All timing and signal generation is done within the FPGA. We won't claim the output is fully VGA compliant, but we have had no troubles using it with a few different monitors we used for testing.

Operating principles

We're generating a 640x480 pixel VGA signal, which involves scanning 800x525 pixels. The extra pixels are hidden in black borders outside the normal display area of the screen (in the front/back porch and rescan areas). For a standard 60Hz monitor update rate, we need a 25.2MHz pixel clock (800 x 525 x 60Hz).

Our alphanumeric terminal occupies a central 512x384 pixel region of the 640x480 display image, with black borders around the edge. We've done this because the 512x384 pixel region maps to 32x16 alphanumeric characters, and 32x16 = 512 which is the number of bytes in each block of RAM within the FPGA.

It would be possible to combine multiple RAM blocks to allow a larger character display (possibly filling the screen), but that would complicate the code design somewhat. Making the relevant changes could be a good exercise for readers who really want to delve into FPGA programming.

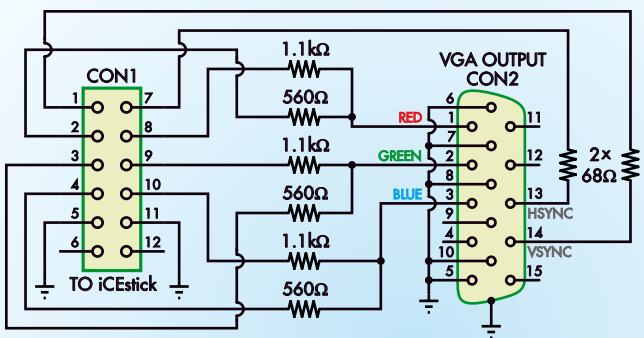
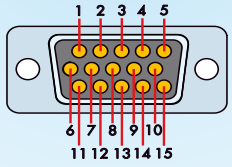


Fig.1: the circuit for our VGA adaptor is delightfully simple, since so much of the hard work is done by reconfiguring the blocks inside the FPGA. Three resistive two-bit DACs are formed by the 1.1kΩ and 560Ω resistors, to control the red, green and blue voltage levels on the VGA connector. The HSYNC and VSYNC pulses are digital signals fed straight to the VGA socket, with 68Ω series resistors for safety. The unusual pin numbering of CON1 is to match the numbering on the iCEstick; they are treated as two side-by-side SIL headers, even though it's physically a DIL header.

SC ©2019 **ICESTICK VGA ADAPTOR**



VGA socket – looking at pins.

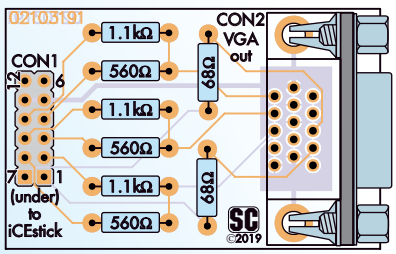
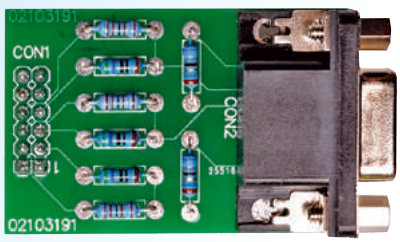
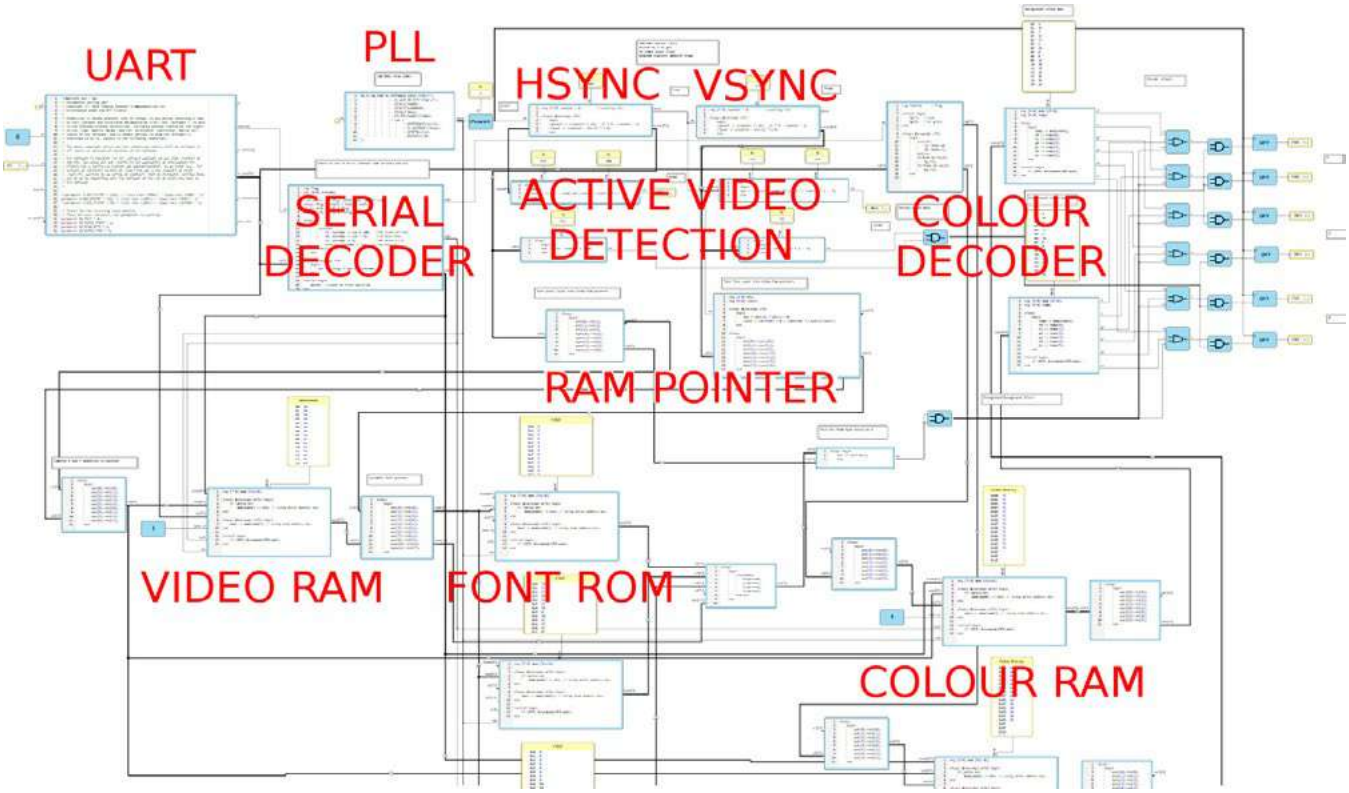


Fig.2: fit the resistors to the PCB where shown here, then the VGA socket, which goes on the same side as the resistors, and finally the 6x2 pin header, on the opposite side. The resulting assembly then plugs straight into the iCEstick and a standard VGA monitor cable.





Screen1: this is a broad map of the functional parts of the "iCEstick VGA Terminal.ice" project. You will need to install IceStudio, download and open that file and zoom in to see the detail of each block.

The FPGA scans the 800x525 area, uses its video RAM to determine which character should be displayed at any given point, then uses the font ROM to determine whether the foreground or background colour should be displayed for each pixel. The HSYNC signal is pulsed at the end of each horizontal scan (ending a line), and the VSYNC pin is pulsed every vertical scan (ending a frame).

Generating the clocks

Since the iCEstick only has a 12MHz oscillator, we need to use the iCE-40HX-1k's phase-locked loop (PLL) to bring that up to around 25MHz. We are generating a 100.5MHz signal, which we divide by four to get 25.125MHz. This is the closest the PLL can get to our target frequency of 25.2MHz, using a 12MHz source. This small error doesn't end up causing any problems.

This clock signal is divided by a factor of 800 in the FPGA, to give a 31.4kHz line clock, then again by 525 to give the frame/screen refresh clock of 59.8Hz. That's 0.2Hz slower than our target of 60Hz, but it isn't uncommon to see video refresh rates that are not an exact number of hertz, and virtually all monitors will handle this.

We have created a 10-bit horizontal pixel counter in the FPGA which starts at zero and counts up to 799, incrementing on each clock pulse (at 25.125MHz), then resets back to zero. Each time it resets, the 10-bit vertical pixel counter is incremented, and it's reset to zero as soon as it exceeds 524. So these two counters allow us to keep track of which pixel is currently being emitted.

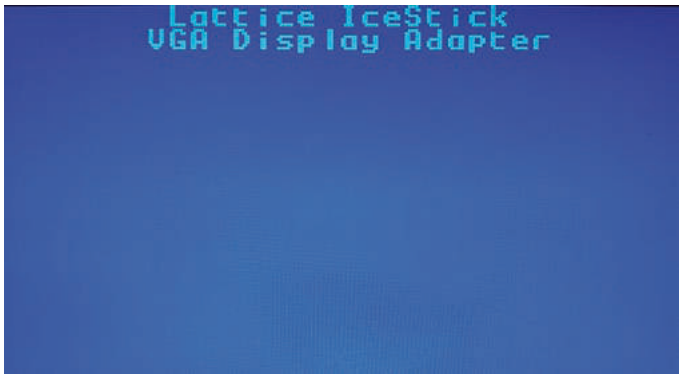
When these pixel values are within the 512x384 active area in the middle of the screen, they are further divided by 16 (horizontal) and 24 (vertical) to determine which character position is currently being displayed. The FPGA then retrieves the 8-bit ASCII character value and two 4-bit colour (background/foreground) values from its video RAM.

The 4-bit colour values are then used to look up the 16-entry palette to determine the 6-bit colour values to use as the foreground and the background for the character currently being emitted. Similarly, the ASCII character value is used to look up an entry in the font ROM.

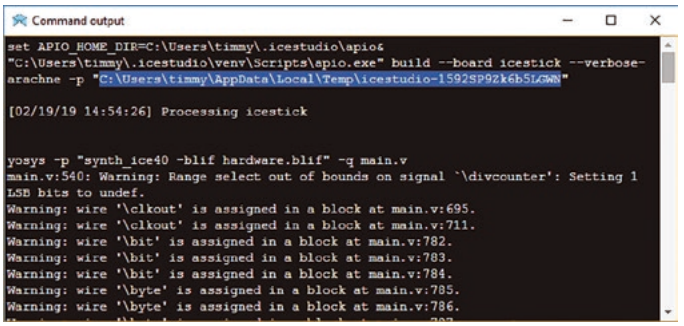
All these lookups culminate in a pixel colour value which is then fed to the RGB outputs (pins 2-4 and 8-10). At the same time, the HSYNC (pin 1) and VSYNC (pin 7) lines are driven based on the horizontal and vertical counters, to generate the required sync pulses for the monitor.

128	64	32	16	8	4	2	1	Decimal	Hex
0	64	32	16	8	0	0	0	120	0x78
128	64	0	0	8	4	0	0	204	0xCC
128	64	0	0	8	4	0	0	204	0xCC
128	64	0	0	8	4	0	0	204	0xCC
128	64	32	16	8	4	0	0	252	0xFC
128	64	0	0	8	4	0	0	204	0xCC
128	64	0	0	8	4	0	0	204	0xCC
0	0	0	0	0	0	0	0	0	0x0

Fig.3: this shows how font glyphs are converted into bitmap values, by adding the value of the pixels that should show the foreground colour. IceStudio expects hexadecimal numbers in the font ROM, so you will need to convert the decimal sums to hexadecimal format (eg, using a programmer's calculator).



Screen2: if you have successfully built the hardware and programmed the FPGA, you will be greeted by this display on your VGA monitor.



Screen3: in the window that appears after clicking View → Command Output, the folder containing the generated Verilog file is visible (highlighted section). Open this folder and find the file named "main.v", which is the generated Verilog equivalent of the IceStudio project.

In more detail, when the horizontal pixel counter is between 0-511, that is the active part of the display, and the RGB outputs are driven. The rest of the time, the RGB outputs remain low, so the front porch, back porch and borders are black. When the horizontal counter is between 592 and 688, pin 7 is set high, creating the HSYNC pulse.

Similarly, the vertical (line) pixel clock counts from zero to 524, with the RGB outputs active from 0-383, and VSYNC is driven high on lines 443-445. The lines between 446 and 524 are the vertical refresh period, so the RGB outputs remain low.

These sync values have been chosen by trial and error, to centre the display on our test monitor.

They can be changed in the FPGA configuration to adjust the location on your monitor, although the differences between the values should remain the same to maintain the same sync pulse widths.

Implementing this in the FPGA

We're using the IceStudio software to demonstrate what can be done using this software, and while the IceStudio project looks quite complicated, it can be broken down into small, easy to understand functional blocks that each accomplish one small task.

We hope this gives you an insight on how easy it is to jump into creating your own projects with Verilog inside IceStudio; keep in mind as you work with FPGAs that the outcome is actually an arrangement of logic gates and flip-flops that all work simultaneously, rather than code that is processed in sequence.

Screen1 shows the IceStudio project in its entirety. The FPGA is configured by connecting various blocks together, and we've labelled groups of blocks to indicate their purpose. If you want to examine the design in more detail as we explain what each block does, skip to the section below titled "Installing the software on your computer", then come back and read the following description.

Clock generation is performed by the area marked PLL in the project window. The code in this block contains synthesiser directives that describe how to configure the PLL. The iCEcube2 software that we reviewed in our iCEstick tutorial on page 32 is capable of generating PLL configuration data if you want to experiment with this block.

To the right of the PLL block and the left of the HSYNC/VSYNC sections are the clock dividers.

The small blue block divides the 100.5MHz clock by four to give the 25.125MHz pixel clock, which is then divided by 800 to give the line clock. This is in turn divided by 525 to give the frame clock.

The ACTIVE VIDEO DETECT sectioncompares the pixel and line clocks to the fixed values indicated above, producing two outputs which are both high when the current pixel is part of the 512x384 pixel active area. These are fed to the colour decoder, which generates black unless both (horizontal and vertical) active video bits are set.

Below ACTIVE VIDEO DETECT is a section which divides the pixel count by two to create indexes for the font ROM. The line count is effectively divided by three, to create the vertical font index.

But rather than using a divider, which would be quite large and complex to implement in the FPGA, instead, a separate counter is used, which is only incremented on every third pulse from the line clock, then reset when it reaches 128 (ie, 384 ÷ 3).

Serial data handling

The FPGA needs to accept serial data from the host, both for configuration and to update the displayed characters and/or colours. The UART block is shown to the left of the PLL in Screen1. This is made using open-source Verilog code that is available at https://github.com/cyrozap/osdvu, which also includes a description of how to interface to it.

We don't need to send any data back to the host, so we removed the transmit-specific sections, to save FPGA resources.

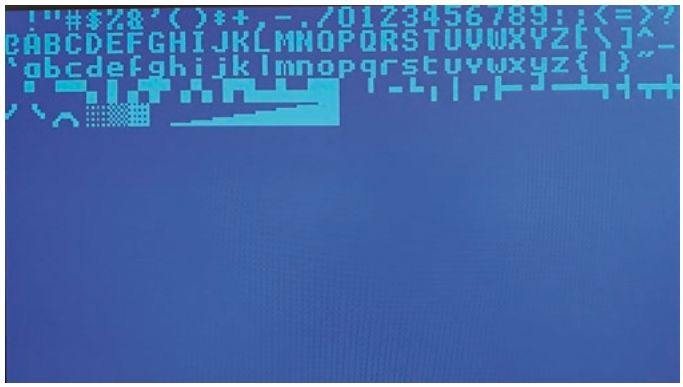
While a microcontroller would wait and then branch to code to read from a buffer when the host is sending data to it, the FPGA is always ready to react, and the data from the UART is put into the video RAM within nanoseconds of it arriving, simultaneously with the video output tasks occurring elsewhere on the chip.

The UART decoder filters the incoming serial data and also holds a vid-

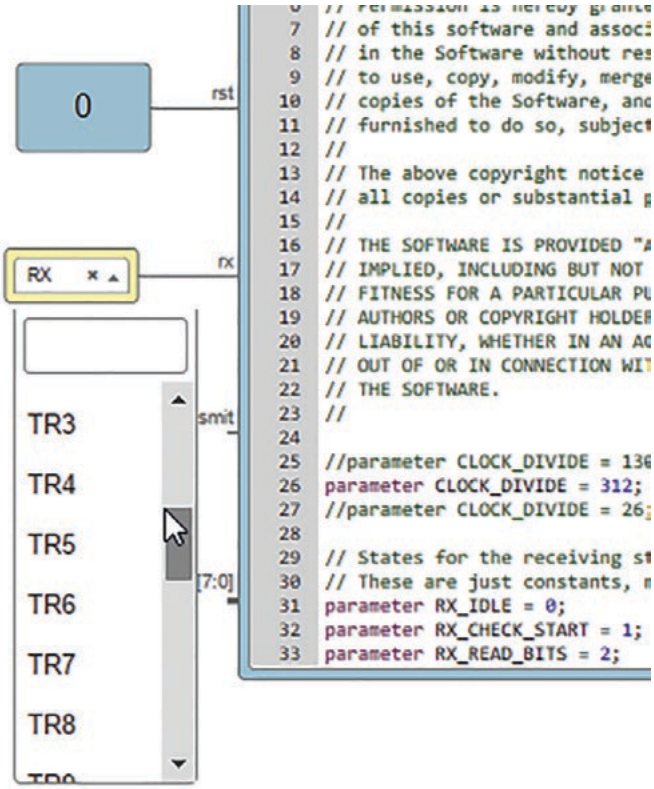
Parts list – iCEstick VGA Terminal

1 Lattice iCEstick FPGA development board
[Mouser 842-ICE40HX1KSTICKEV, Digikey 220-2656-ND]
1 double-sided PCB, code 02103191, 49.5 x 32mm
1 2x6 male pin header (CON1)
1 DE-15 (or HD-15) high-density 15-pin female D-connector (CON2) [AMP 1-1734530-1, MULTICOMP SPC15430]

Resistors (all 1/4W 1% metal film)
3 1.1kΩ 3 560Ω 2 68Ω



Screen4: the default character map/font for the iCEstick VGA Terminal. It can be changed by editing the font ROM blocks. The first three lines are the standard ASCII characters at positions 32-127, followed by some pseudo-graphics characters that can be used to draw boxes, bar graphs and so on.



Screen5: the RX (receive) pin of the UART module can be changed using this drop-down box. Not all pins in the list can be used; for example, we are already using all the PMOD pins for the VGA output.

eo RAM pointer. This filtering checks the three high order bits of each received character. If all of these are low, then received serial data ASCII value is less than 32. That means that it is a control byte and processed as such.

The control bytes work as follows. A carriage return (code 13) causes the video RAM pointer to be reset to the start of its line by ANDing its value with 32. A line feed (code 10) moves the pointer to the next line by adding 32, and a form feed (code 12) moves the cursor to position zero by resetting the pointer, as though starting a new page.

If the received data value is 32 or higher (and thus an ASCII character), the received character is written to the video RAM at a position corresponding to the pointer's value and the pointer is incremented by one. Thus characters received consecutively appear at consecutive locations on the display

The currently selected foreground and background colour combination is also written to a separate RAM which is used to later decode the colour data for display.

Other control codes are decoded by the small block to the left of the colour decoder. Code 14 sets a flag so that the background colour is set, while code 15 sets the flag to the foreground. If a value from 16 to 31 is received, it is sent to the foreground or background register per the flag.

Because all except the lower four bits are ignored here, code 16 selects colour 0 and code 31 selects colour 15 from the palette.

Screen6 shows the default palette of colours that are available.

The video RAM section takes an address value made from combining parts of the horizontal and vertical 'scan' position. The small code box on the left just combines the bits to create a linear address.

Video RAM

The larger box is the video RAM itself. This has been coded in a specific way to use part of the iCE40HX-1k's BRAM (block RAM). If not done in quite the right way, the memory is synthesised from flip-flops instead of using the dedicated block RAM. This alternative is a very poor use of resources; as an experiment, we tried this, and found that the 512 bytes of RAM took about half of the FPGA's flip-flop resource.

The iCE40HX-1k contains 16 separate 512-byte blocks of double-ported RAM. The double-port feature means that it can be read and written at the same time, which is essential in our application because we may be trying to change the display at the same time that the VGA display logic is reading from it (as it is reading video RAM almost constantly).

The small beige block above the video RAM initialises it at startup to display some splash-screen text. If you don't want this, replace the contents of the beige block with zeroes, or your own hexadecimal values for a custom splash screen.

The small block to the right of the video RAM generates an address into the font ROM, based on the ly displayed character value from video RAM and the vertical position of the scan.

Font ROM

The font ROM consists of three BRAM blocks, each fed by a separate initialising block. While implemented using RAM blocks, there are no connections to the write lines, so they remain unchanged as long as the FPGA is powered, and are effectively read-only.

By using multiple BRAM blocks and a four-way multiplexer, we can overcome the 512 byte limit of each block (hint: this might be a good way to expand the video RAM). Each BRAM block encodes 64 characters in eight bytes each, for a total of 512 bytes. There's room to add a fourth BRAM block below, but we only need 192 characters in the font ROM, so we have not done so.

Each byte of the font ROM encodes a horizontal line of eight pixels as a bitmap. The small block next to the font

Screen6: these are the colour combinations that can be displayed by the iCEstick VGA Terminal. The characters shown at each column are combined with the Control key to create the foreground colour shown in many serial terminal programs. These 16 colours are selected from a set of 64 possible colours; you can modify the ROM values in the IceStudio project to choose different ones.

ROM decodes the horizontal character sub-position into a single bit; it is effectively an eight-to-one multiplexer. The output of the font ROM is a single bit indicating whether the foreground or background should be displayed for the current pixel.

Colour

In a similar fashion to the way the video RAM is read, data is read from the colour RAM to determine the combination of foreground and background colours to be displayed at the current scan position. This is a separate RAM block that uses the same address and clock lines as video RAM as its input. The output of the colour RAM is fed to the colour decoder.

The colour decoder has a pair of small 6x16 bit ROMs, which are initialised by the beige blocks above them. These decode the 4-bit colour palette index value into the necessary output pin states to generate that specific colour in the palette. The two blocks are identical; one is used to decode the foreground colour and one the background colour, to simplify the following logic.

The colours have been chosen based on those used in the venerable Commodore 64, which also had a 16-colour display.

To the right of the ROMs are a row of multiplexers, one for each output pin involved in driving the VGA colour lines. The multiplexer chooses between the foreground and background colours according to the line from the font ROM.

This is followed by an AND gate. The data from the multiplexer is ANDed with a bit that indicates if the current scan position is inside the central 512x384 pixel box, in which case the foreground or background colour is produced. Otherwise, the result is low, so the outputs of all the AND gates are low and therefore all the output pins are low and black is displayed.

Finally, a D-flipflop is used to buffer this signal into the output pins, so that their states only change on the pixel clock. This ensures our pixels are not subject to jitter and thus line up squarely on the screen. The result is a very stable display.

Installing the software on your computer

To build this project, you need to install the IceStudio integrated development environment (IDE) software. There are versions available for Linux, Windows and macOS. If you've been reading our FPGA tutorial, starting on page 32, you may have already installed it. Otherwise, follow the installation instructions at: **https://github.com/FPGAwars/icestudio**

We used version 0.4.0. Once installed, you should also install the toolchain and enable the driver for the iCEstick (only needed on Windows).

If you're unsure how to do this, read the aforementioned tutorial, which explains this in detail, or read the IceStudio documentation at: **https://icestudio.readthedocs.io/en/latest/**

Now download the "iCEstick VGA Terminal.ice" file from our website and open it in IceStudio. You will see something similar to what's shown in Screen1 above, and you can now examine the blocks in closer detail.

If you need to change any of the configuration parameters, such as the serial port baud rate, these are 'hard coded' into the project, so you will need to change the .ice file using the IDE graphical interface.

Other settings that can be changed include the colour palette and font glyphs. Details on how to change all these parameters are given below.

By default, the serial interface is connected to iCEstick's USB/serial converter IC, but this could be remapped to an external I/O pin for interfacing with a microcontroller such as an Arduino board or MicroMite.

Construction

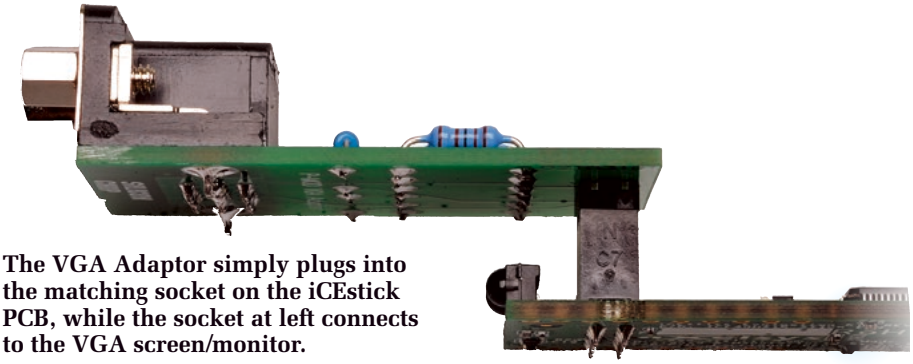
As you can see from the PCB overlay diagram, Fig.2, there are few components on the board so it shouldn't take long to build.

The board is coded 02103191 and measures 49.5 x 32mm.

Start by fitting the two 68Ω resistors; these are closest to CON2. Bend the legs at right angles, put through the holes and splay the legs to hold in place. Solder and trim the leads just above the solder fillet on the reverse of the board. Fit the 560Ω and 1.1kΩ resistors using a similar procedure.

Now mount the VGA socket next, ensuring it is properly seated and flush with the PCB. Solder the larger mechanical pins, turning up your soldering iron temperature if necessary.

Carefully solder the fine pins of the signal lines to avoid bridging adjacent pins.



The VGA Adaptor simply plugs into the matching socket on the iCEstick PCB, while the socket at left connects to the VGA screen/monitor.

You may find it easier to work with the centre row of pins first, and ensure that they are soldered and tidy before accessing the outer rows, which have more surrounding space to work with.

Finally, fit the 2x6 pin header. This sits underneath the PCB, on the opposite side to the other components, and is soldered from the top.

Avoid excessive heat, as this may melt the plastic shroud, putting the pins out of alignment.

Check that there are no solder bridges or short circuits, and plug the board into the PMOD header of the iCEstick. The VGA socket faces away from the USB plug of the iCEstick.

Plug a VGA cable from the VGA socket to a monitor or television.

Building and uploading the code

With the "iCEstick VGA Terminal.ice" file open in IceStudio, select the iCEstick from the Select → Board menu. To synthesise the design, click Tools → Build, and when the green "Build done" message appears, click Tools → Upload.

The keyboard shortcuts for these commands are Ctrl-B and Ctrl-U respectively.

Now connect a VGA monitor and check to see if you have a display, similar to that shown in Screen2. If you have a terminal program installed, such as TeraTerm, PuTTY or even the Arduino IDE, figure out which serial port the iCEstick is using and open a connection to it at 9600 baud with eight bits, no parity (8-N-1).

Type into the terminal, and you should see text appear on the screen. If the 'Enter' key generates a CR/LF pair in your terminal program, pressing Enter should cause subsequent text to appear at the start of the next line. Assuming your terminal program supports control codes (which most do, except for the Arduino IDE), you can change the colours by using control key combinations.

ASCII control codes 1-26 correspond to pressing Ctrl and one of the letters A-Z on the keyboard; as A is the first letter of the alphabet, Ctrl-A sends control code 1. Press Ctrl-N or Ctrl-O to switch between setting the foreground or background colour, and press Ctrl-P through to Ctrl-Z to change that colour.

The five remaining codes between 27 and 31 map to a combination of Ctrl plus another key, those keys being "[", "\", "]", "^" and "_", respectively.

You can now use the iCEstick VGA Terminal as-is, or you may wish to experiment further to see what is possible with IceStudio.

Debugging the project

While the block-and-wire methodology of creating a design does not leave much opportunity for errors, manually entered code blocks certainly could be erroneous, and thus can cause a build error. In this case, you will see a red bar appear instead of "Build done" after attempting a build.

It's possible to view the entire Verilog file that is generated during the build process. IceStudio converts the graphical design into a text-based (Verilog) HDL file, then builds that into the binary bitstream. That's an intensive process which involves figuring out which FPGA resources can be used to create the required logic and how they should ideally be interconnected, so it can take some time.

To view the generated Verilog, click on the View → Command Output menu option and open the folder shown in Screen3. In this folder, there is a "main.v" file, which is the Verilog code that IceStudio has generated.

If you do get a build error, scroll towards the bottom of the Command Output window and you should see an error message indicating the line number on which the error occurred (and the nature of the error). This, in combination with the generated Verilog, should help lead you to the source of the error.

It's a good idea to open "main.v" in a text editor which displays line numbers. When building the project, you may also see some warnings; most warnings can safely be ignored.

Verilog code blocks

Now that you know how to debug the code, you may wish to dabble with the Verilog inside the code blocks in this project. Here are some tips to get you started; but don't think this is the complete book on Verilog coding! Like the C language, all statements end with a semi-colon.

Some lines in the Verilog code are direct assignments, such as the following used to generate the HSYNC signal. These generate simple digital logic:

```
assign out = ((count < stop) &&
  (count >= start)) ? 1 : 0;
```


WOW! A high performance, Arduino-based, digital
LC METER
that measures from PicoFarads to Farads & NanoHenries to Henries!
See SILICON CHIP June 2018 (Article 11099)

Uses Arduino Uno (or equivalent)

Just look at these incredible features:
• Inductance measurement range 10nH – 1H (+) • Capacitance measurement range 0.1pF – 1F (+)
• Advanced calibration • Continuous drift compensation • Long-term averaging • Automatic component detection
You'll find this advanced Digital LC Meter is one of the handiest devices you can have on your workbench!

Specialised and hard-to-get parts are available from the SILICON CHIP Online Shop:
PCB (incl. headers) (SC 04106181) $7.50
20x4 alphanumeric LCD (SC 4203) $15.00
1nF 1% NPO/C0G capacitors (SC 4273) (Pk 2): $5.00
Custom laser-cut Acrylic Case: (SC 4609) $7.50
All other components (including Arduino Uno) are commonly available from your normal parts supplier

Here, the ternary operator (? :) assigns the "out" register the value of 1 (high) if the value of "count" is less than "stop" and equal to or greater than "start". Otherwise, "out" is assigned the value 0 (low).

This could pass for valid C code, apart from the 'assign' keyword, but it should be remembered that we are synthesising hardware in the form of logic gates rather than compiling machine code.

At a few places in this project, we want to increment a counter based on an input, for example:

```
reg [9:0] counter = 0;
  always @(posedge clk)
    begin
      counter <= (counter ==
div - 1) ? 0 : counter + 1;
      clkout <= (counter <
div/2) ? 1 : 0;
    end
```

This code is in the block that divides the pixel clock down to a line clock. The first line specifies that "counter" is a 10-bit register, and is set to zero on power-up.

The second line indicates that the following sequence will only occur on the positive edge of the "clk" signal. The resulting synthesis will use flip-flops to retain the state of the registers between "clk" pulses.

The begin/end statements are used to group the two following lines so that they both occur inside the 'always' block.

Here, "counter" is incremented (ie, its value is increased by one), unless it has reached one less than the value of "div", in which case it is reset to zero.

Thus, "counter" counts from zero to div-1, which gives us our horizontal pixel position in the "counter" register.

The "clkout" register is set to one while "counter" is in the bottom half of its cycle (less than div/2), and zero when it is in the top half, thus dividing the incoming "clk" signal by the ratio of "div".

This "clkout" signal is fed into another similar code block, so that every time the horizontal counter reaches zero, the vertical counter is incremented. This is how our raster is generated.

You might note that these registers are loaded with a "<=" symbol instead of a "=".

The "<=" means that they are non-blocking assignments, so they are considered to occur simultaneously.

If a specific order of assignment is needed, then the "=" blocking assignment operator can be used to enforce this, particularly if the result of one expression depends on the result of a previous expression.

The memory block demonstrates a few other features of Verilog. Using this specific form of assignment is needed to enforce the use of block RAM, as mentioned earlier:

```
reg [7:0] mem [511:0];

  always @(posedge wclk) begin
    if (write_en)
      mem[waddr] <= din;
end

  always @(posedge rclk) begin
    dout <= mem[raddr];
end

  initial begin
    if (MEM)
   $readmemh(MEM,mem);
  end
```

The first line defines an internal register file "mem", which has 512 (511-0) eight-bit (7-0) elements, effectively, an array. The first "always" block is responsible for writing to the memory, where the 8-bit value "din" is stored at position "waddr" in "mem" on the positive edge of "wclk", but only if "write_en" is high (one).

The second "always" block performs a read, loading the value of the memory (mem) at "raddr" to the "dout" register on the rising edge of "rclk". Block RAM is always synchronous (requiring a clock) on the iCEstick's iCE40HX-1k.

Changing the baud rate

We suggested earlier that some of the features such as baud rate, graphics and colours can easily be modified. The baud rate is controlled by a single value within the UART block.

Around line 26 inside the UART block is the definition of the CLOCK_DIVIDE parameter.

You can select 115200 baud by commenting (adding '//' to the start of) this line:

```
parameter CLOCK_DIVIDE = 312;
```

and removing the '//' from the start of

```
//parameter CLOCK_DIVIDE = 26;
```

Note that the CLOCK_DIVIDE value is determined by dividing 12,000,000 by four times the baud rate (or 3,000,000 divided by the baud rate) and choosing the next lower integer.

Choosing the next lower integer means the baud rate is slightly faster than desired, but this will handle receiving a steady stream of characters better than a slightly slower baud rate.

Changing the font

The font ROM consists of groups of eight 8-bit hexadecimal values inside the three FONT blocks. The top-most block encodes ASCII codes 0-63, the second 64-127, and the third 128-191.

The most significant bit is at left, and the least significant bit at right, with the data in rows in order from top to bottom.

Refer to Fig.3, which shows how the letter "A" is encoded (it is found at addresses 0x08 to 0x0F near the top of the second font ROM block).

The whole font is shown in Screen4.

Changing the colours

The colours are formed by a similar bitmap, with sixteen 6-bit hexadecimal entries.

The two most significant bits are for the blue level, the middle two bits for the green, and the bottom two bits for red.

Thus 0x00 is black and 0x3F is white, as per the first two entries, with the third entry 0x03 being red.

Because the foreground and background colours are stored in separate ROMs, you could provide different colour maps for each, but that might be a bit confusing to use.

I/O pin assignments

Finally, you may wish to map the serial data to a different pin, so you aren't using the USB/serial converter. This is done by changing the pin connected to the "rx" input of the UART module, as shown in Screen5.

We recommend using the "TR" or "BR" groups of pins for I/O; these are the rows of solder pads along the edges of the board.

Refer to the iCEstick manual to check which pin is which.

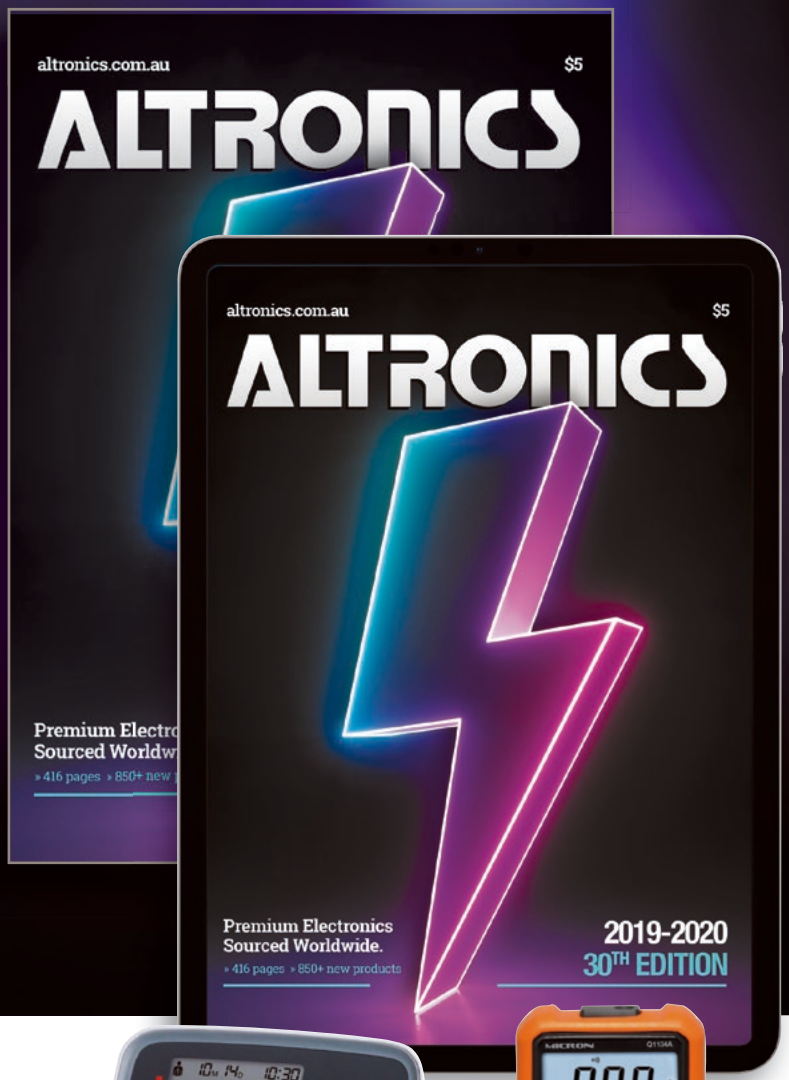
Take care as the pins are only rated for 3.3V I/O levels, so directly connecting a 5V microcontroller is not recommended, and a level converter or voltage divider should definitely be used in that case. SC

NEW ALTRONICS CATALOGUE OUT NOW!

An indispensable resource for your projects in the year ahead!

- Over 800 new products.
- 416 pages - our biggest edition ever.
- A great reference for the workbench.

Register to receive a complimentary copy by post at: altronics.com.au/catalogue



NEW!

Control more with 2 shields!

K 9670A **$120**

MK2 Arduino MegaBox Kit by Altronics.

Upgraded for 2019! Developed in house by Altronics, this new revised MegaBox is an upgrade of our original K 9670 - adding space for two shields, plus FIVE 2A 5V relay outputs and eight opto isolated outputs on the rear. All UNO/Mega pins are broken out to header sockets for easy connection to other breakouts. A small 210 hole prototyping area on the main board is included for connecting to other sensors, parts and circuits. *Note: Arduino board and shields not included.

Addressable RGB Full Colour LED Matrix Panels

These linkable panels are ideal for making highly visible scrolling signs, information readouts, clocks and timers. Readable up to 52m away! 5mm pitch LEDs.
Z 6518: 384x192mm.
Z 6517: 192x192mm.

$59 Z 6517 32x32

$99 Z 6518 64x32

X 4003A **$74.95**

Home Blood Pressure Monitor

Save a fortune on regular doctor and pharmacy visits to monitor your blood pressure. This handy meter records your measurements so you can monitor changes over time. Also includes an irregular heartbeat monitor. Stores readings for 2 people. Requires 4xAA batteries (S 4906 $4.95).

NEW MODEL!

Z 6453 **$189**

Educational Smart Turtle Robot

Easy to program 2 wheel, Arduino based, obstacle avoidance and line tracking robot. The front of the robot features a 5x5 LED panel which can display icons, text and symbols (or display the direction of travel). It is controlled via Bluetooth on your tablet + IR remote. Requires 2x18650 lithium cells.

NEW MODEL!

Q 1134A **$39.95**

Auto Ranging True RMS Meter

With non-contact AC voltage detection in-built! An affordable auto ranging meter with True RMS accuracy for AC voltages. Plus temperature measurement! (probe included).

NEW!

Solder Splice Joiners

By popular demand! Heat up and join cables together without the need for manual soldering. Melts at 450°C. Packs of 6.

Size	Model	ONLY
White 26-24AWG Pk6	W 0800	$4.25
Red 22-18AWG Pk6	W 0804	$4.50
Blue 16-14AWG Pk6	W 0808	$4.75
Yellow 12-10AWG Pk6	W 0812	$4.95

See last page for store locations or visit altronics.com.au

Sale pricing ends April 30th 2019.

Power up your Easter break!

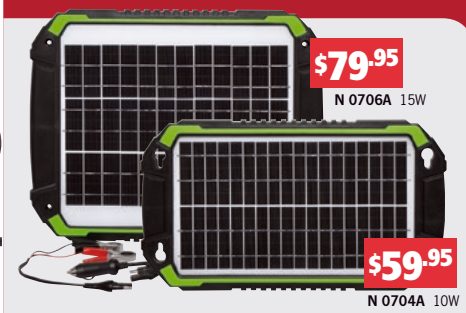
120W Folding Solar Panel With Regulator

Going bush? Have power wherever you go on your next 4WD adventure.

• Includes 120W panel, solar regulator, battery connection cables and canvas carry case. • 3 stage solar charger ensures your batteries are performing at their peak! • Adjustable stand for best sun placement. • 720x520x70mm (folded).

Laptop & USB Car Charger

Simply plugs into a car accessory socket. Up to 90W power output. Includes 9 laptop adaptors - see web for compatability list.



Efficient Solar Battery Chargers

These compact monocrystalline solar panles are designed for keeping your car, caravan or 4WD batteries topped up, but can be adapted to replenish batteries in any remote DC power installation. Croc clip or car accessory plug connection. 10W: 377L x 212W x 17D mm, 15W: 40L x 343W x 17Dmm.

Need an extra laptop charger for work?

This powerful 45W USB-C power delivery (PD) charger offers fast recharging for the latest MacBooks, Nintendo Switch, notebooks and other type "C" equipped devices. Also provides two standard type "A" USB outputs.

Phone Holder with Wireless Charging

Simply place your phone in the holder to keep it topped up whilst you're driving! Convenient windscreen or air vent mounting. Great for Uber drivers or road reps.

Cable free phone charging on the go!

• Slim 10,000mAH design • QI wireless charging pad • Works with iPhone 8/X • Includes USB cable.

Inflate a tyre. Start a flat battery.

Great gift idea for the 4WD or car enthusiast. Features a 16800mAh battery bank plus emergency compressor to top up tyres (max 8 mins run time). Provides 600A peak battery cranking output. 12/16/19V & USB output provided for powering devices.

Mini Car Phone Holder

• Suits phones up to 85mm wide • Grips securely to your air vent

USB C Type QC3.0 In-Car Charger

Need to keep your laptop charged up in the car? No problem! This powerful C tyle charger provides QC3.0 charging capability up to 18W output.

Panel Mount Volt/ Ammeter

Reads 6-30V DC voltages up to 10A current. Internal shunt. Suits P 0679/80/81 facia plates. 28mmØ mounting hole.

4 Way Quick Charge 3.0 USB Charger

'Charge IQ' feature charges a connected device at the fastest speed. 4A max current. 110-240V - great for travel. Includes mains lead. 62W x 97D x 31Hmm.

USB NiMH/NiCad Charger

Charges 4 x AAA/AA cells via USB. Great for use at home or in the car. Use rechargeables & save batteries from landfill!

Dual 12V Battery Isolator Kit

Provides everything you need to wire up a secondary battery in your vehicle - vital for powering appliances at campsites, inverters etc, and isolating the primary battery so you have enough juice to start your car! Instructions included.

Mains Power Anywhere, Anytime!

Great for camping, farmers, mobile trades, service vans. • Host of protection features • Soft start • High/low voltage shutdown

Rating	Model	Normally	ONLY
12V 150W	M 8072	$59.95	$44
12V 300W	M 8076A	$79.95	$58
12V 600W	M 8084	$129	$95
12V 1000W	M 8090	$235	$175

Answer the door when you're not home!

Wi-Fi Video Doorbell with smartphone app control and 2 way audio. This stylish doorbell connects to your wi-fi and notifies your phone when a person arrives at your doorstep. Great for telling the postie where to put packages.

• Security camera mode • Motion detect notification • Remote door unlock function (when used with a suitable doorstrike) • Includes power supply.

Mini Magnetic Door Chime/Alarm

Alerts you when a door or window opens with an alarm or chime. Great for notifying you when customers arrive at your business. Simple two piece design with adhesive backing. Requires 2xAAA batteries.

HALF PRICE!

C 0866

$174

Opus One® 8" Wall Speakers

PLUS BONUS BACKBOXES VALUED AT $45! (C0869)

Featuring woven carbon fibre woofer & titanium dome tweeter for the ultimate in home theatre response! • Bass & treble control switches • Vented magnets • Easy flip-lock installation • Rust free aluminium grilles

HALF PRICE!

$199 C 0857

Opus One® 8" Ceiling Speakers

Featuring woven carbon fibre woofer & titanium dome tweeter for the ultimate in home theatre response! • Bass & treble control switches • Vented magnets • Easy flip-lock installation • Rust free aluminium grilles

$85 SAVE $44

A 2795

Upgrade your alarm clock to digital radio.

The ideal bedside companion to wake up to your favourite digital or FM station. Large colour TFT display shows time and scrolling digital radio information. (displays analog clock and date when radio is off). 20 channel presets. Two alarms. Size: 135L x 110W x 90Hmm.

Also relays IR signals back to your source equipment.

$259 SAVE $140

A 3601

Send HDMI signals wirelessly!

Designed to send a 1080p HDMI signal wirelessly up to 35m line of sight using 5GHz band for reliable transmission. Supports full 7.1ch surround. Includes plugpacks.

Low Profile TV Wall Brackets

Affordable mounting for screens up to 50" (max 50kg). Includes handy spirit level. Tilting model offers -5 to 15° tilt.

Great for the bed room or kids space!

$29 HALF PRICE! H 8090A Fixed

$54 HALF PRICE! H 8100A Tilting

Reclaim your desk space!

$64 HALF PRICE! H 8230

Desk Monitor Mount

• Easy adjust arms - stays where you put it! • USB ports for easy peripheral connection • Monitors up to 30" • Desk clamp installation. • Max individual monitor weight 9kg.

Handy AV System Savers!

$64 HALF PRICE! C 0844

Weatherproof 6x9" Vehicle Speakers

Maintenance free outdoor sound. These weatherproof 6x9" speakers are designed for long life in marine or tropical areas. Also great for caravans. 30W RMS. 4Ω.

Small on size, big on sound!

Subtle appearance with swivel mount drivers these mini cube speakers are ideal for the kitchen, study or bedroom. 15W 8Ω. Size: 130Hx65Wx75Dmm.

C 5283

$54 HALF PRICE!

Wall Mount Your Monitors

Quality speaker brackets rated to 10kg each. 20° tilt, 180° pan. Width 190-300mm

H 8061

$49/pr HALF PRICE!

$109 SAVE $40 A 2384

Extend your sound system with ease!

Connect up to two additional pairs of speakers to your stereo amp without risk of damage. Each speaker "zone" has on/off & volume control. 50W RMS per channel (4/8Ω speakers).

HALF PRICE!

$149

A 2554

Top Value Redback® 5 Channel Audio Mixer

Compact & easy to use mixer. 5 channels accept up to 11 inputs. 3 band EQ, channel volumes, crossfader & VU meters. Great for schools and small venues.

D 2815

All your home entertainment in one box.

Stream direct to your TV from your favourite services such as Netflix, YouTube and more! Capable of streaming stunning 4K videos @ 60fps! Requires 2A USB power supply. Pair it with our A 0981 wireless keyboard/trackpad for $29.95.

$59 SAVE $50

No cable termination required!

$115 SAVE $30 PB7309 20m

$125 SAVE $40 PB7311 30m

Run HDMI over longer lengths!

Latest technology leads fitted with booster unit to allow for longer cable runs. Plugs and booster fit down standard 25mm electrical conduit for easy installation.

An alternative to Apple Airpods for a fraction of the price!

$59 SAVE $40

C 9037

Includes carry case charger.

No 3.5mm jack on your phone?

No worries! These new Jabees Shield 'true wireless' bluetooth earbuds are perfect for exercise - they're sweat resistant, light weight and provide 9hrs of listening time. Includes charging case and replacement earbuds.

A 0930

$89 SAVE $30

Infra-Red Extender Kit

Got your AV equipment in a cabinet or rack? This handy bi-directional IR extender kit will relay control signals between two locations. Powered by USB port on your TV/amp. Includes emitter & target.

4K Upscaler & Audio Extractor

Scale 1080p to 4K/2K res. Plus optical audio output. Includes plugpack.

$59 SAVE $20

A 3834

Upgrade your work bench!

$169

T 2694

Iroda® 30W Lithium Ion Soldering Kit

• High efficiency • Compact • Easy to use. 45 minute run time - 2500mAh - 600°C max. Kit includes 3 tips & carry case. The perfect iron for field techs or working with automotive cabling etc. Easy to stay recharged on the job - recharge from flat in 3.5hrs.

T 2065

$175

SAVE $40

Micron® Vacuum Desoldering Station

Designed to desolder through hole componentry, removing molten solder quickly and easily from solder pads and parts. In-handle reservoir is easily removed and cleaned. Includes three desoldering tip, nozzle cleaner and filter pads. 160°-480°C.

$29

SAVE 27%

Q 3003

Waterproof design for field use!

Detect lethal AC voltages instantly.

This non-contact probe detects cabling and power outlets with live AC power (100-1000V). An essential preventative tool for trades people. Waterproof case with in-built torch.

Just 16mm thick!

$50

SAVE $39

Space Saver Multimeter

Not much bigger than your average mobile phone, this auto ranging meter saves space in your tool box. Easy to use with volts, current, amps and resistance. **Q 1064**

iroda

High Output Blow Torch

Super hot 1350°C flame with high output nozzle. Handheld or self standing design for tasks such as heatshrinking, model making, silver soldering! Easy to refill.

NEW MODEL!

T 2496

$70

$26

SAVE 20%

T 2164

Phone Repair Kit

Everything you need to disassemble most phones and tablets - driver bits, plastic & metal spudgers, suction cup and more!

$50

SAVE $29

Q 2030

HDMI Cable Tester

A fast way to check pin to pin integrifty of HDMI cables in AV installations. Requires 9V battery.

$99

NEW!

T 1297

Swing Arm Benchtop Fume Extractor

Whisk away irritating solder fumes instantly as you work. The replaceable active carbon filter absorbs fumes for a cleaner work environment. Includes 100mm ducting adaptor. Easily screw clamps to your work bench.

T 2749

$45

SAVE 24%

Superb quality for precision use.

Tungsten 5" Precision Side Cutters

Super sharp with HRC72° hardened jaws provides 5 times the life of standard sidecutters.

AC/DC Clamp Meter

Accurately measures AC or DC current to a 600A! Includes True RMS AC measurement, resistance, temperature, capacitance, zero & hold functions - All supplied with carry case & test leads.

SAVE $60

$129

Q 0966

SAVE $50

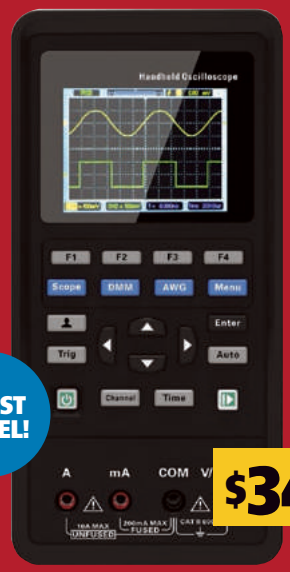
T 2178

$165

10 Crimping Tools In One!

Virtually every crimper you'll ever need! 10 sets of quick change magnetic jaws to suit kwik crimps, uninsulated lugs, telephone lugs, ferrules, coax crimps, D-Sub pins & RJ plugs.

New Release.



LATEST MODEL!

Q 0102

$349

Powerful diagnosis tools in the palm of your hand.

All the power of a benchtop oscilloscope in the palm of your hand. This compact digital storage oscilloscope and digital multimeter makes field testing easy, even when working in tight spaces or with equipment on site. Offers 2 channels with real time sampling of 125MSa/s per channel with waveform comparison tools and a full range of accessories (plus carry case).

ALTRONICS

Build It Yourself Electronics Centres

VIC

» **Springvale:** 891 Princes Hwy 03 9549 2188
» **Airport West:** 5 Dromana Ave NEW! 03 9549 2121

NSW

» **Auburn:** 15 Short St 02 8748 5388

QLD

» **Virginia:** 1870 Sandgate Rd 07 3441 2810

SA

» **Prospect:** 316 Main Nth Rd NEW! 08 8164 3466

WA

» **Perth:** 174 Roe St 08 9428 2188
» **Balcatta:** 7/58 Erindale Rd 08 9428 2167
» **Cannington:** 5/1326 Albany Hwy 08 9428 2168
» **Midland:** 1/212 Gt Eastern Hwy 08 9428 2169
» **Myaree:** 5A/116 N Lake Rd 08 9428 2170

Or find a local reseller at:

www.altronics.com.au/resellers

B 0091

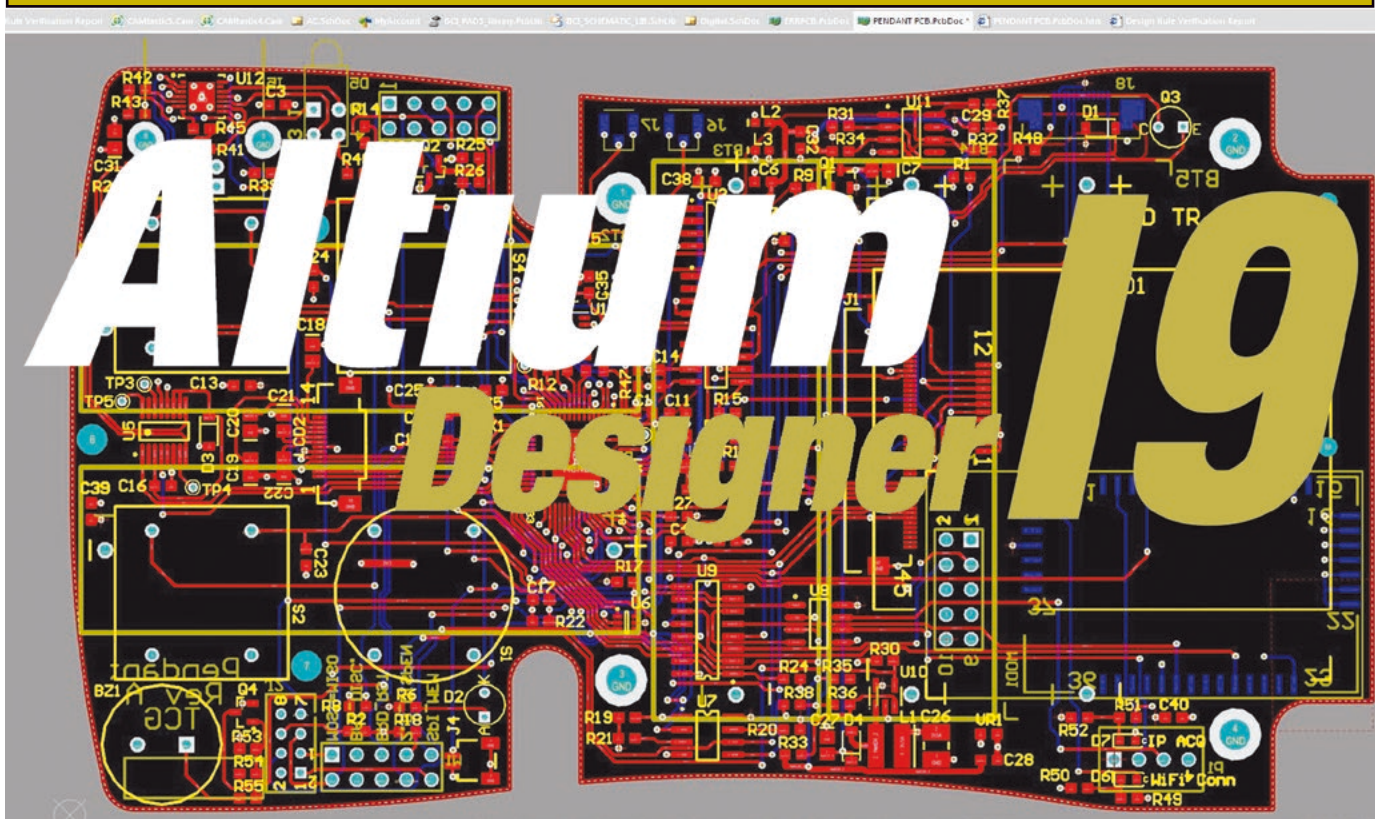
Please Note: Resellers have to pay the cost of freight & insurance. Therefore the range of stocked products & prices charged by individual resellers may vary from our catalogue.

Sale Ends April 30th 2019

Phone: **1300 797 007** Fax: **1300 789 777**
Mail Orders: **mailorder@altronics.com.au**

© Altronics 2019. E&OE. Prices stated herein are only valid until date shown or until stocks run out. Prices include GST and exclude freight and insurance. See latest catalogue for freight rates.

“Hands on” review by Tim Blythman



Altium Designer 19 is the latest incarnation of the PCB design software that we’ve been using at SILICON CHIP, in one form or another, for over 20 years. While the changes are more evolutionary than revolutionary (compared to the big step that was Altium Designer 18), there are definitely some great new features to discover.

It’s now 2019, and that means that Altium Designer 19 is available. If you were on the ball, you might have even noticed that it was released in mid-December last year, less than a year after Altium Designer 18.

You can see our comprehensive review of Altium Designer 18 in the August 2018 issue of SILICON CHIP (siliconchip.com.au/Article/11189).

Altium Designer 19 is the latest generation of EDA (electronic design automation) software that began over 30 years ago as the Australian product, Protel PCB. Effectively a tool for turning a circuit idea into a finished PCB, Altium Designer is the tool we use at SILICON CHIP to design PCBs for all our projects.

We’ve now been using Altium Designer 19 for around a month and are quite happy with the improvements we have seen in that time.

Installation

AD19 is a 1.9GB download which uses up about 4.9GB of storage space after installation. To install it, you first download a small (~20MB) program which then downloads and installs the rest by itself.

There was an option to transfer our settings from a previous version of Altium Designer, which we took, and it did transfer all our settings across, although it didn’t bring over our recently used documents list.

This review is of version 19.0.10, which was the latest version available at the time of testing. Altium usually releases a few updates to each major version of Designer over the year, presumably to fix bugs that were reported or discovered during that time.

Component re-route feature

This is one of the new features that many people are sure to make good use of. In practice, it’s certainly not perfect, but it’s worth using.

The situation is this: you have placed and routed a small group of components, perhaps an IC and its associated passives, but then you realise that the entire group needs to be moved for whatever reason.

Previously, you would have to do a fair bit of track rerouting. At the very least, you would move the group of primitives, including the parts and their interconnecting tracks, and then try to fix up the now mangled external connecting tracks, getting them to where they need to go without short circuits or clearance violations. In the worst case,

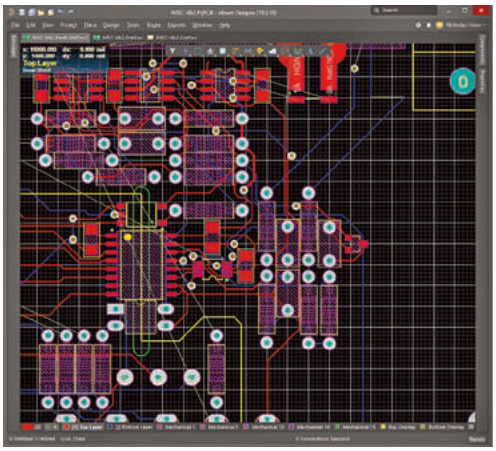


Fig.1: a section of a PCB we are currently working on, where we want to move a large group of components to the right.

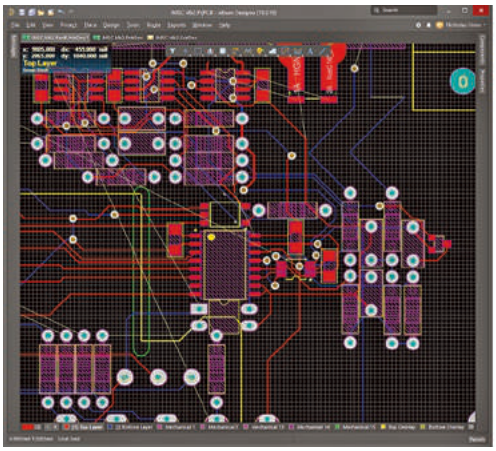


Fig.2: AD19's Component reroute feature has been enabled, so after moving them, most of the external tracks are still connected correctly, and there are no apparent design rule violations as a result of the move.

you may have to reroute all the tracks around those parts.

Component re-route is the solution to this. As the name suggests, when this feature is enabled, tracks are re-routed whenever components (or a group of components) are moved, reducing the need to do this manually.

Fig.1 shows a PCB we're working on while Fig.2 shows the result of moving a large group of components 5.08mm to the right, with this feature enabled. You can see that many of the tracks connecting these components to other parts of the circuit have changed shape to preserve those connections and prevent overlaps and short circuits.

Some of these tracks would need to be manually cleaned up as they have become unnecessarily 'loopy', but it's a lot less work than re-routing all the tracks manually. Fig.3 further demonstrates how re-laid tracks do not always end up finding the obvious paths. But the resulting layout is still valid, even if non-optimal.

When this feature is enabled, there's a brief pause after each movement, while the track paths are recalculated according to the current design rules. So you certainly don't want to have it switched on all the time. There are times when you may even need to move a component out of the way temporarily, in which case you don't want the connected tracks to follow.

This feature can be switched on and off via the Preferences dialog box (available either from the Tools menu or the gear icon on the menu bar), under PCB Editor → Interactive Routing → Component re-route (see Fig.4).

Follow Mode for routing tracks

One routing feature which we would have certainly used in the past, had it been available at the time, is the Follow Mode for track placement. You might notice that our PCB design for the Stackable LED Christmas Tree published in the November 2018 issue (**siliconchip.com.au/Article/11297**) has some curved tracks that gently follow the contours of the board.

This was painstakingly done by creating an arc, assigning it to a net, then adjusting it for the correct radius, and finally connecting the tracks at each end. Both sides of the PCB have a pair of stacked arcs, for a total of four, so this took some time to accomplish.

AD19's Follow Mode allows the interactive routing to follow the contours of an object (which may be composed of several smaller primitives such as lines and arcs). The new version would have allowed us to simply start the track, switch to Follow Mode to create a gentle arc along the board edge, and then resume normal routing.

To activate Follow Mode, start routing a track as usual, and then when you have reached the obstruction, move the mouse pointer over the obstruction and press Ctrl-F. The track will now consist of arcs and line segments following the contour of the obstruction until the left mouse button is clicked, after which normal routing resumes.

Interactive routing design rules are obeyed during Follow Mode, of course, and the results can be seen in Fig.5.

In addition to this new feature, the routing algorithm has been generally improved and seems to be slightly smarter

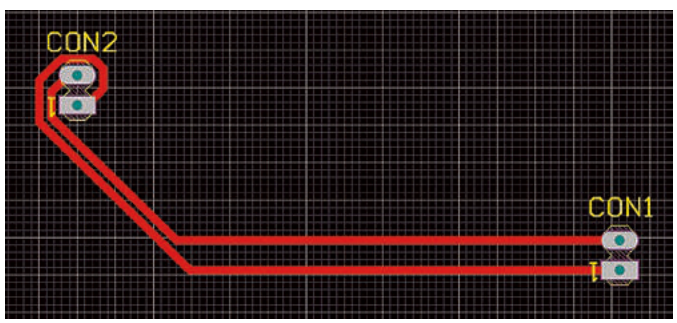


Fig.3: here we tried to move CON2 with Component re-route turned on; the tracks were originally parallel. This only happened very occasionally, but it was quite surprising when it did happen.

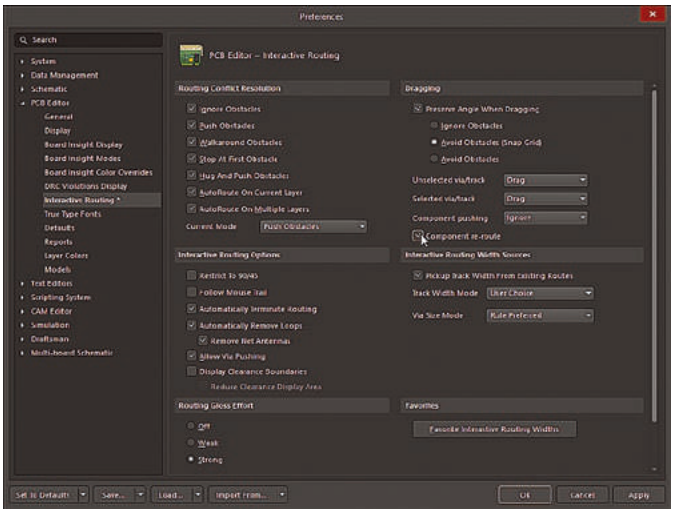


Fig.4: this shows where the Component re-route option can be enabled or disabled in the Preferences. Click OK after changing the setting for it to take effect.

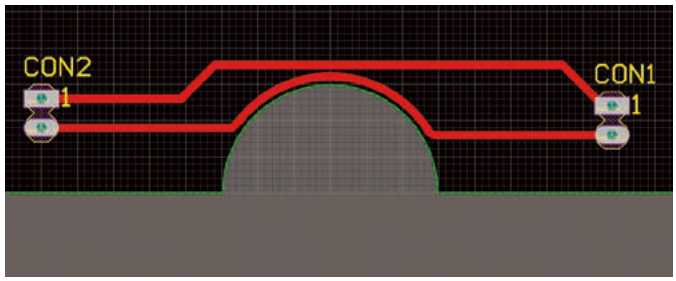


Fig.5: using Follow Mode on the lower track produces a neater result and allows better use of board space.

than before. It will now more reliably detect if the track has looped back upon itself, and close the loop to shorten the track. Sometimes you don't want that, though, so that feature can also be turned off in Preferences.

Advanced Layer Stack Manager

We do not use the Layer Stack Manager to any great extent as our designs typically have only two layers on standard FR4 substrate (with a couple of four-layer exceptions), and usually don't have any special requirements regarding high-frequency operation. But this new feature would be useful for those that do have such special requirements, such as with many RF boards.

The new version of the Layer Stack Manager uses a material library to keep track of which material characteristics (such as copper weight and dielectric thickness and other properties) can be used on a given PCB. The layer stack can then be assembled from the library of known materials.

This allows customisation of the board's impedance characteristics, for both single conductors and differential pairs. Given accurate material information, the Impedance tab allows quantities such as impedance, propagation delay, track inductance and track capacitance to be easily calculated.

An example of the result of these calculations being displayed is shown in Fig.6. This dialog also shows how

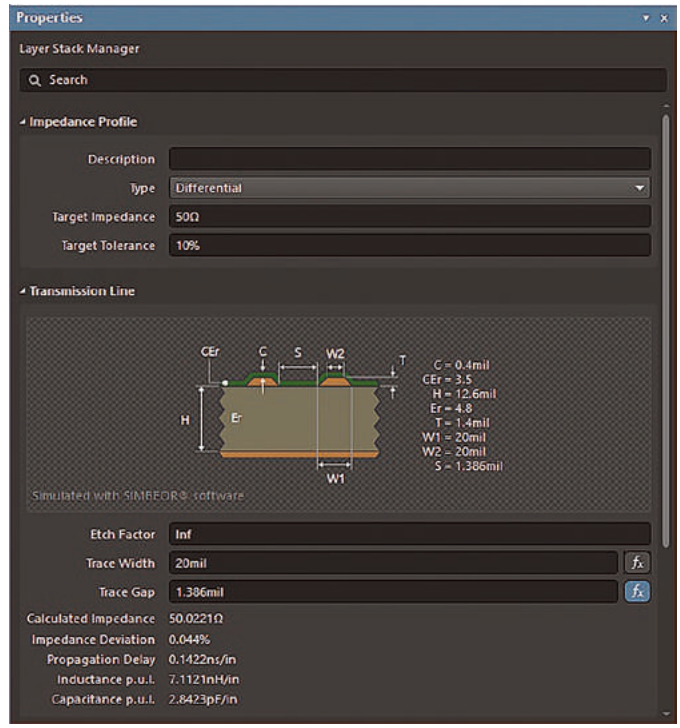


Fig.6: the Impedance tab of the advanced Layer Stack Manager provides the option to fine-tune track impedance and other characteristics for both single-ended and differential tracks.

the software uses the stack material data to calculate the dimensions for laying tracks with a controlled impedance for differential signalling.

Printed electronics support

One of the more unusual ways of creating circuits is the use of printed electronics. This involves printing conductive layers on an insulating substrate to build up the circuit, rather than the more traditional method of removing

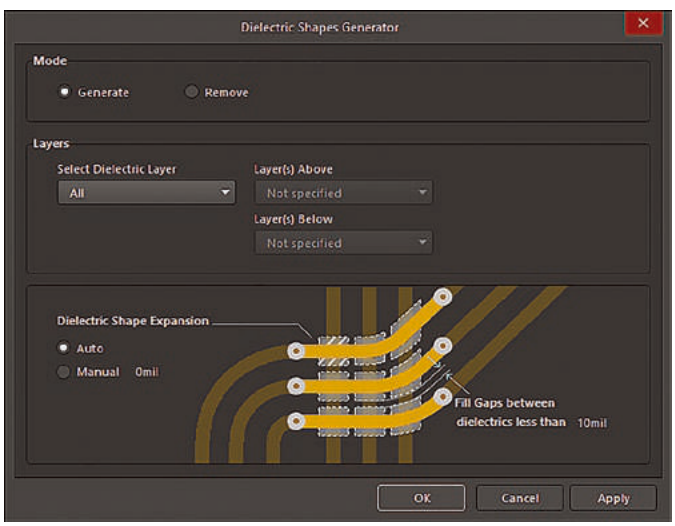


Fig.7: the Dielectric Shapes Generator dialog box gives an idea of how some types of printed electronics can be fabricated, using minimal areas of dielectric material which are used to separate conductors that would otherwise produce a short circuit.

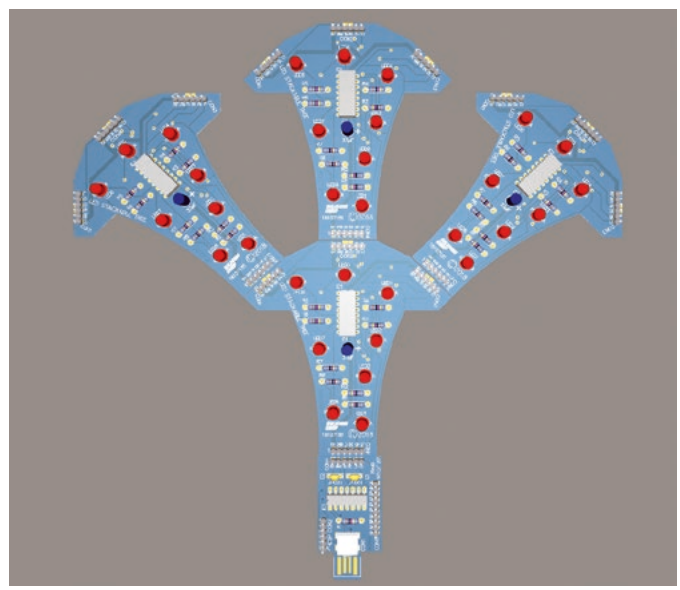


Fig.8: the Multi-Board Assembly tool can be used to see how a design composed of multiple components, including PCBs and other parts, comes together as a whole. Here we have combined four copies of our Stackable LED Christmas Tree with the USB Digital Interface board.

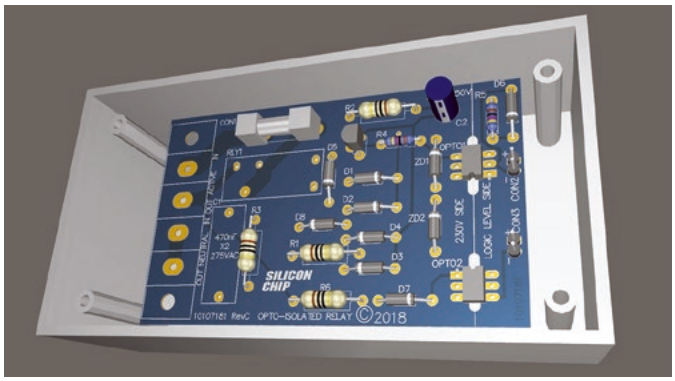


Fig.9: using the Multi-Board Assembly feature, we have placed the PCB for the Opto-Isolated Relay into a UB3 jiffy box. If we then added 3D footprints for the relay and capacitor, a relatively simple job, we could then check that the assembled PCB fits in the enclosure before even having the boards manufactured.

copper in unwanted areas which were pre-laminated onto the substrate.

Multiple circuit layers can be added by placing insulating or dielectric material between the conducting layers. As such, the PCB layout process is much the same in principle, except that the shapes for the intervening dielectric layers need to be generated, not just those for the conducting tracks.

Altium Designer 19 can work with such designs and generate the dielectric shapes.

This is controlled through the Layer Stack Manager, where the Features option is set to "Printed Electronics". The layer stack itself should be modified to suit the design; typically, there is no bottom silkscreen as there is no easy way to print it onto the bottom layer due to the order of printing.

With printed electronics, the conducting layers are generally not made of copper; normally a conducting polymer is used, with significantly more resistance. Its properties can be set in the Layer Stack Manager too. An AD add-on is required to generate the shapes on the insulating layers, and this can be installed by finding the "Dielectric Shapes Generator" in the Extensions and Updates tab.

Once the tracks have been laid, the Dielectric Shapes Generator is run from the Tools → Printed Electronics → Dielectric Shapes Generator menu. The dialog box which appears is shown in Fig.7. This will give you an idea of how the various layers pile up, and how the dielectric shapes create the necessary separation.

Some emerging PCB prototyping technologies will use printed electronics techniques. There are even some people modifying 3D printers to extrude conductive filament or modifying ink-jet printers to lay down conductive ink at the moment.

The output of the Printed Electronics mode is standard Gerber files as per a regular PCB design, and these files could even be a handy option for anyone who develops a method of printing in conductive inks at home.

Multi-board assemblies

We noted in our review of Altium Designer 18 that it introduced better integration of multi-board designs, and it made the creation of flexible designs easier too. In fact, practically any rigid design could be made into flexible version by substituting a flexible dielectric layer for the rigid fibreglass layer (and many PCB manufacturers can do this for you, for a price!)

But this becomes more difficult when you need to combine both types of board in a design. Not only do you need to visualise how the boards themselves come together but you must also determine how they fit together with other parts such as enclosures.

To test this out these multi-board assemblies, we created an assembly of a few of our Stackable LED Christmas Tree boards, mentioned earlier, along with the compatible USB Digital Interface board that was published in the same issue (siliconchip.com.au/Article/11299).

The resulting assembly can be in Fig.8. This would have come in handy while we were designing that project, as we had to resort to printing the PCB pattern and making paper cutouts to check that the boards would stack and fan out neatly.

The steps required to implement muti-board assemblies involve creating the various PCBs and, if you wish to include enclosures, 3D STEP file representations of them. A "Multi-Board Assembly" is created, and the various parts added and moved into place in a 3D view, not unlike the 3D view accessible from the PCB layout tab.

As we noted, it is possible to incorporate enclosures into a multi-board design to be able to see how the entire product fits together. We think that this is actually the most useful aspect (for us, anyway) of the Multi-board feature; to see how complete assemblies fit in enclosures.

That would be true whether we are trying to fit one board or several into an enclosure; we do the latter from time to time, with more complex designs. As an example, Fig.9 shows a mock-up of the 230V Opto-Isolated Relay board (October 2018; siliconchip.com.au/Article/11267) fitting inside a UB3 jiffy box.

When you bring the various parts of the project together, you will then be able to see whether there are any conflicts, for example, components that would foul parts of the case, such as the lid.

If you find such a problem and need to modify one of the PCBs (or even the case) to fix it, once the source files are changed, the complete assembly can be refreshed with the modified parts to confirm that the changes fix the problem.

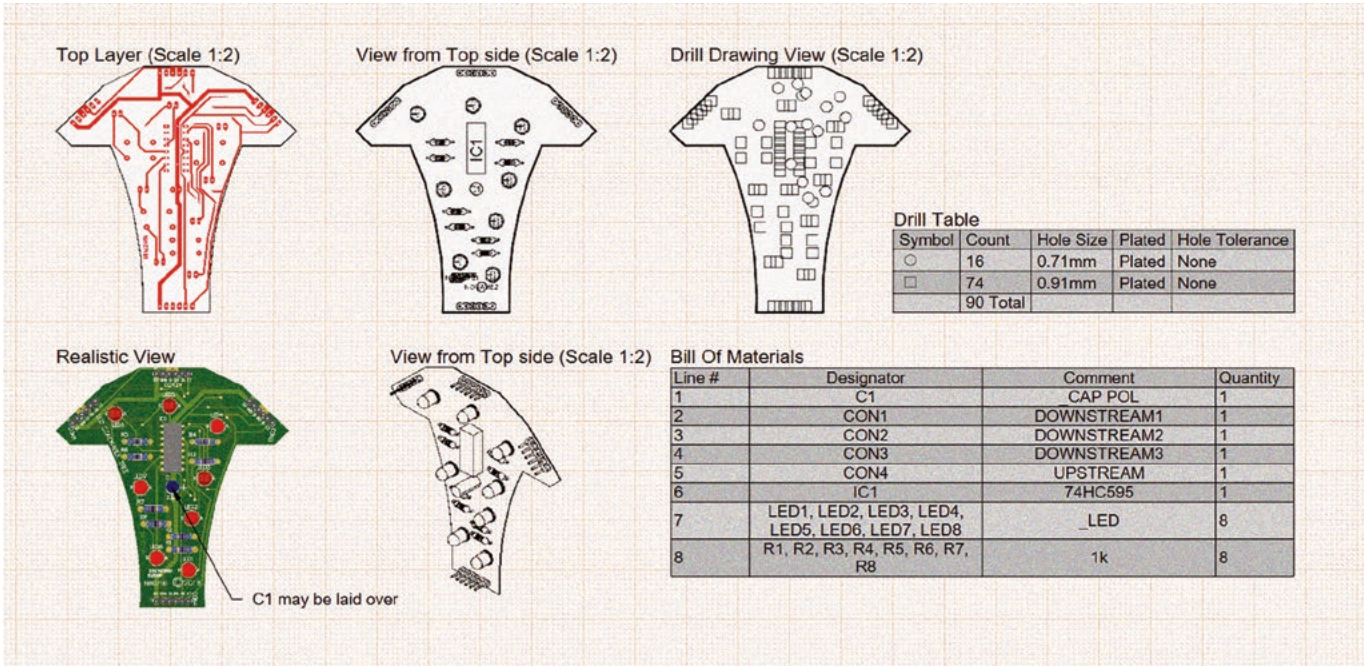
When using off-the-shelf enclosures, it is easy to do a real-world test fit, but there would be many companies (and even individuals with 3D printers) who are designing their own enclosures, making this a bit more difficult. This feature gives the option of being able to test fit many parts without waiting weeks for samples to be manufactured for test fitting.

Another potential use for the multi-board assemblies feature is using the 3D renderings and visualisation to demonstrate to potential customers or others what a product under development will look like when complete.

3D Export

Completed multi-board assemblies (and even plain PCBs) can now be exported as 3D STEP files too, allowing 3D representations of the assembly to be used in other applications.

You could, for example, use a 3D printer to print dummy versions of the PCB for mechanical testing, or import the 3D object into another application that is not able to accept Altium's normal file format.



Symbol	Count	Hole Size	Plated	Hole Tolerance
○	16	0.71mm	Plated	None
□	74	0.91mm	Plated	None
	90 Total			

Line #	Designator	Comment	Quantity
1	C1	CAP POL	1
2	CON1	DOWNSTREAM1	1
3	CON2	DOWNSTREAM2	1
4	CON3	DOWNSTREAM3	1
5	CON4	UPSTREAM	1
6	IC1	74HC595	1
7	LED1, LED2, LED3, LED4, LED5, LED6, LED7, LED8	_LED	8
8	R1, R2, R3, R4, R5, R6, R7, R8	1k	8

Fig.10: this shows some of the representations that can be created using the Draftsman feature. The top layer view and drill drawing view could be used by the PCB manufacturer to confirm the PCB design and the lower views can be used to confirm that the final assembly is correct.

Draftsman tool

While the Multi-Board and Assembly feature allows the finished product to be visualised, there is also the Draftsman tool to help communicate how the product should look at various stages of manufacture, and to assist those involved in manufacturing. It is a way to quickly create several smart-looking diagrams and tables to help communicate the intent of the design.

We tried it out, again using the Stackable LED Christmas Tree design, and in a few minutes, we were able to create what can be seen in Fig.10. You would have to agree that the result looks pretty spiffy!

In use

The change from Altium Designer 18 to Altium Designer 19 is not a big as the step up to Altium Designer 18 was, from previous versions. Ignoring the added and improved features, nothing appears to have moved from where we expected to find it. So workflow is unaffected.

That's important since you build a lot of "muscle memory" using software like this long-term and breaking old habits can take months, and can slow you down initially. While we ultimately like many of the changes introduced with AD18, it did take some time to get used to them!

Of course, finding and activating some of the new features will involve knowing where to find the setting in the first place, but a quick web search to figure that out (or the time taken to read this article) is certainly worth the time saved by a really useful and time-saving feature like Component re-route.

Altium 365

Another tool has been announced in conjunction with Altium Designer 19 is Altium 365. It is touted as a cloud-based tool for collaboration, and will also allow access to projects by stakeholders via a browser, as well as from within the Altium Designer application.

It appears that Altium 365 will allow people to contribute to and be updated on projects without needing the full Altium Designer application.

Users of Altium Designer 18 or older will need to upgrade to Altium Designer 19 to make use of Altium 365. At the time of writing, Altium 365 is undergoing beta-testing and we have not tried using it.

The verdict

We have not looked back at Altium Designer 18 since installing Altium Designer 19. Now that we have settled into how the newer versions (18 and 19) work compared to the older versions (17 and older), Altium Designer 19 appears to provide the small, but useful improvements that we expect from a newer version.

As noted, some of the new tools appeared to be something we would not necessarily make use of, but we certainly can see the utility. These are not useless "bells & whistles" as you sometimes find in other software. For example, using the Multi-board Assembly to check how an enclosure fits would be handy if we did not have the time to wait for prototypes to be manufactured.

Altium gives the option of installing the two versions alongside each other, so that if you have any doubts about how the newer version works, you can always try Altium Designer 19 on a trial basis. But we think that, like us, you will be happy to make the switch.

We have installed new versions side-by-side with older versions in the past, only to find that the old version gathers dust (so to speak), and is eventually removed to save some storage space.

More details?

You'll find much more information about Altium 10's many features (more than we had space for here), free trial software, etc on Altium's website: www.altium.com.au SC

Your Favorite Development Tool Just Got Better

MPLAB® PICkit™ 4 In-Circuit Debugger - More Functionality and Faster Programming at the Same Low Price

There's a new hero in town: the MPLAB® PICkit™ 4 In-Circuit Debugger. Available at the same low price as its predecessor—the popular PICkit 3 debugger—it enables faster programming and offers more functionality for easy debugging of the full range of PIC® microcontrollers and dsPIC® Digital Signal Controllers with Flash memories. To boost your application development, the MPLAB PICkit 4 debugger includes these key features:

- Uses powerful graphical user interface of MPLAB X Integrated Development Environment
- Wide target voltage of 1.20-5.5V; target power of 50 mA
- Matches the silicon clocking speed to provide the fastest programming possible
- Connects to PC using Hi-Speed USB 2.0 interface
- Programmer-to-Go (PTG) support with an SD™ card slot to hold program data

MPLAB PICkit 4
In-Circuit Debugger
(PG164140)

Contact Information
Microchip Technology Australia
Email: aust_nz.inquiry@microchip.com
Phone: +61 (2) 9868-6733

microchip.com/PICkit4

MICROCHIP

The Microchip name and logo, the Microchip logo, dsPIC PIC and MPLAB are registered trademarks and In-Circuit Serial Programming and PICkit are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries. All other trademarks are the property of their registered owners.
© 2019 Microchip Technology Inc. All rights reserved.

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Simple zener diode tester fits inside a DMM

I wrote into Silicon Chip (Mailbag, November 2018) to whinge about the fact that very few (if any) DMMs available these days include a zener diode testing function, despite this being a very handy thing to have. The circuit presented here shows just how easy it is to add such a function.

I even managed to fit it in the free space inside a Digitech QM-1500 DMM I purchased from Jaycar, despite it being built on a piece of veroboard. It makes you wonder why the manufacturers can't do this!

It's a great Saturday arvo project since it's pretty quick and easy to build and doesn't use any exotic parts. You probably already have them all in your junk box, which means it will cost you little-to-nothing to build it.

The first step is to figure out how much space you have inside your DMM. In my case, I found I could fit a board about 55 x 18mm behind the LCD screen. That equates to a piece of veroboard with seven copper strips.

The circuit only uses about a dozen components and is powered from the DMM's internal 9V battery.

When externally accessible push-button switch S1 is held down, current flows from the battery through LED1 and its 4.7kΩ series current-limiting resistor, so LED1 illuminates to indicate that the zener testing mode is operational.

Current also flows through the 100Ω resistor and through one half of transformer T1, to the collector of Q1. At the same time, current flows to Q1's base through the 100Ω and 470Ω series resistors and the other half of T1.

As Q1 switches on and the current through the top half of T1 increases (at a rate limited by its 220µH of inductance), current induced in the other half of the transformer opposes the base current to Q1, cutting it off and causing it to switch off. Then, as the current through the top half of T1 drops, the base current flow resumes and Q1 can switch on again.

Thus, it forms an oscillator, which oscillates at around 85-90kHz.

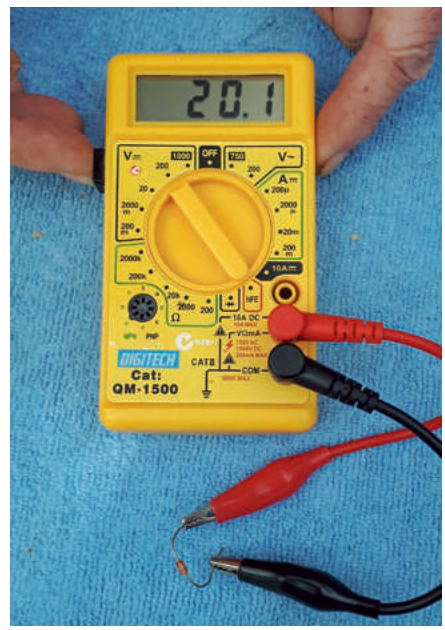
This allows the transformer, in combination with diode D1 and the 1µF capacitor, to form a simple DC/DC boost converter, which provides a little over 50V (at light loads) for testing zener diodes.

This is sufficient for testing most zener diodes you will come across. The zener clamps this voltage at a level depending on its type, and the DMM is used in DC voltage measuring mode to show that voltage.

The choice of a BC337 for Q1 is a compromise. A BC546 or BD681 will get a higher output voltage at the expense of much higher (double!) the current drain on the battery.

The 68Ω resistor limits the maximum current through the zener being tested to about 2mA but the circuit can only deliver around 3mA continuously to a low-voltage zener, decreasing to around 0.1mA for a 28V+ zener. Despite this variation, the results should still be pretty accurate.

D2 is provided merely as a safety feature, to prevent a voltage that is applied to the meter leads from damaging the circuit. Note that D2 will still conduct if you apply a negative or AC



The zener diode tester board (55 x 18mm) fit in the free space at the top of a Digitech QM-1500 DMM. The zener is connected with cathode to positive lead. If connected the wrong way around, you will measure the zener's forward voltage.

Circuit Ideas Wanted

Got an interesting original circuit that you have cleverly devised? We will pay good money to feature it in Circuit Notebook. We can pay you by electronic funds transfer, cheque or direct to your PayPal account. Or you can use the funds to purchase anything from the SILICON CHIP Online Store, including PCBs and components, back issues, subscriptions or whatever. Email your circuit and descriptive text to editor@siliconchip.com.au

voltage to the multimeter terminals while pressing S1.

The second pole of double-pole pushbutton switch S1 disconnects the circuit from the test terminal when it isn't in use, so that it does not interfere with the other functions of the DMM.

Assembly

T1 was wound on a toroidal ferrite core of 9mm OD, 5mm ID and 6mm thick. It was bifilar wound with 18 turns of 0.3mm enamelled copper wire.

Make sure you connect the start and finish of each winding with the orientation shown in the circuit diagram. If the oscillator doesn't work, try swapping the start and finish of either winding but not both.

The size of the toroidal core is restricted by the space available inside the DMM. If you don't have a suitable one in your junk box, you could try stacking two Radio Spares Cat 467-4239 cores. You may need to modify some of the component values to get the desired performance.

When building the board, the layout is not critical but keep the leads to T1 short.

For S1, I used a tactile membrane switch, mounted on the outside of the DMM (see photo) and wired to the battery and veroboard. You only need to make three connections to the board: the ground and V+ test lead (via S1) and the +9V supply from switch S1.

Using it

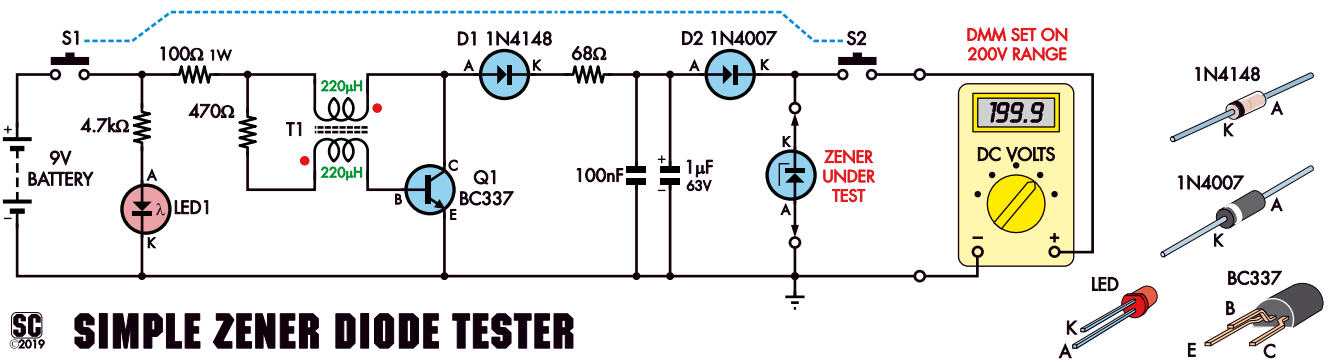
The zener to test is connected like a resistor when you measure resistance, but the polarity matters. If connected the wrong way around (with the anode to the positive lead), you will simply measure the forward voltage of around 0.6-0.7V.

Switch the DMM to a suitable DC voltage scale and press S1 for 1-2 seconds. I find the accuracy to be surprisingly good.

You should keep presses of S1 brief since the circuit draws about 60mA from the battery during the test. But you would have to use this mode a lot to significantly reduced the battery life, as long as you keep the presses short.

You can check the condition of the battery using the same procedure but with no device connected. If the battery is good, you will get a reading above 50V.

Colin O'Donnell,
Adelaide, SA ($70).



Automatic sleep timer for TVs

If you have the same problem that I do, of falling asleep in front of the TV, you will find this simple modification to an existing kit very handy indeed.

Some TVs include a sleep timer function – mine does, but I find it very awkward to use. So I came up with this design as a simple way of switching the TV off automatically.

It's based on the PIR-Triggered Mains Switch project, published in the February 2008 issue. That's still available as a Jaycar kit, Cat KC5455. You only need a few extra parts to modify the kit, which you can also get from Jaycar.

The result is a mains timer which can be set for a timeout of between 7.5 seconds and about two hours, which is automatically reset each time you press a button on your TV remote control.

So as long as you use the remote at least once every hour or so (to change the volume, channel, whatever), the TV will remain on. If you fall asleep, unless you're pressing buttons in your sleep, the TV will eventually switch off!

If you wake up later and still want to watch TV, all you have to do is hit a button on the remote to reset the timer and switch the TV back on. (Or you could leave it off and go to bed…)

There are just five parts that need to be added to the circuit, shown in a cyan-shaded box.

REG1 and its output filter capacitor provide a regulated 5V rail to run infrared receiver IRD1.

When you press a button on your TV remote control, the signal is picked up by IRD1 and its output goes low. That results in pin 4 of CON1 being pulled low, via 1N4148 diode D7 and the 3.3kΩ resistor.

The lowest negative-going voltage threshold for the input of a 4093B (pin 2 of IC1a) with a 12V supply is 3.5V (the highest threshold is 5.4V).

Taking into account the forward

voltage of D7 and the voltage divider effect of the 3.3kΩ and 10kΩ resistors, with the output of IRD1 low, the voltage at pin 2 of IC1a should be 3.4V (0.6V + 11.4V × 3.3kΩ ÷ 13.3kΩ), just below that threshold.

We don't want IC1a's output to go high (because of its input voltage being low) when there is no IR activity, ie, when pin 1 of IRD1 is high.

In that case, the voltage at pin 2 of IC1a would normally be around 7.2V (5V [IRD1] + 0.6V [D7] + 6.4V × 3.3kΩ ÷ 13.3kΩ), well above the 5.4V worst-case threshold which might trigger the timer reset.

Note that the PIR-Triggered Mains Switch PCB has provision for mounting a 3-way terminal block in place of CON1, which provides all the connections you need to add the extra circuitry.

Its terminals connect to the 12V supply, pin 2 of IC1a and ground.

So you could wire up that extra circuitry on a small piece of veroboard, mount it so that the infrared receiver pokes through a hole drilled in the front panel, then just run three wires back to that terminal block (or solder them straight to its pads).

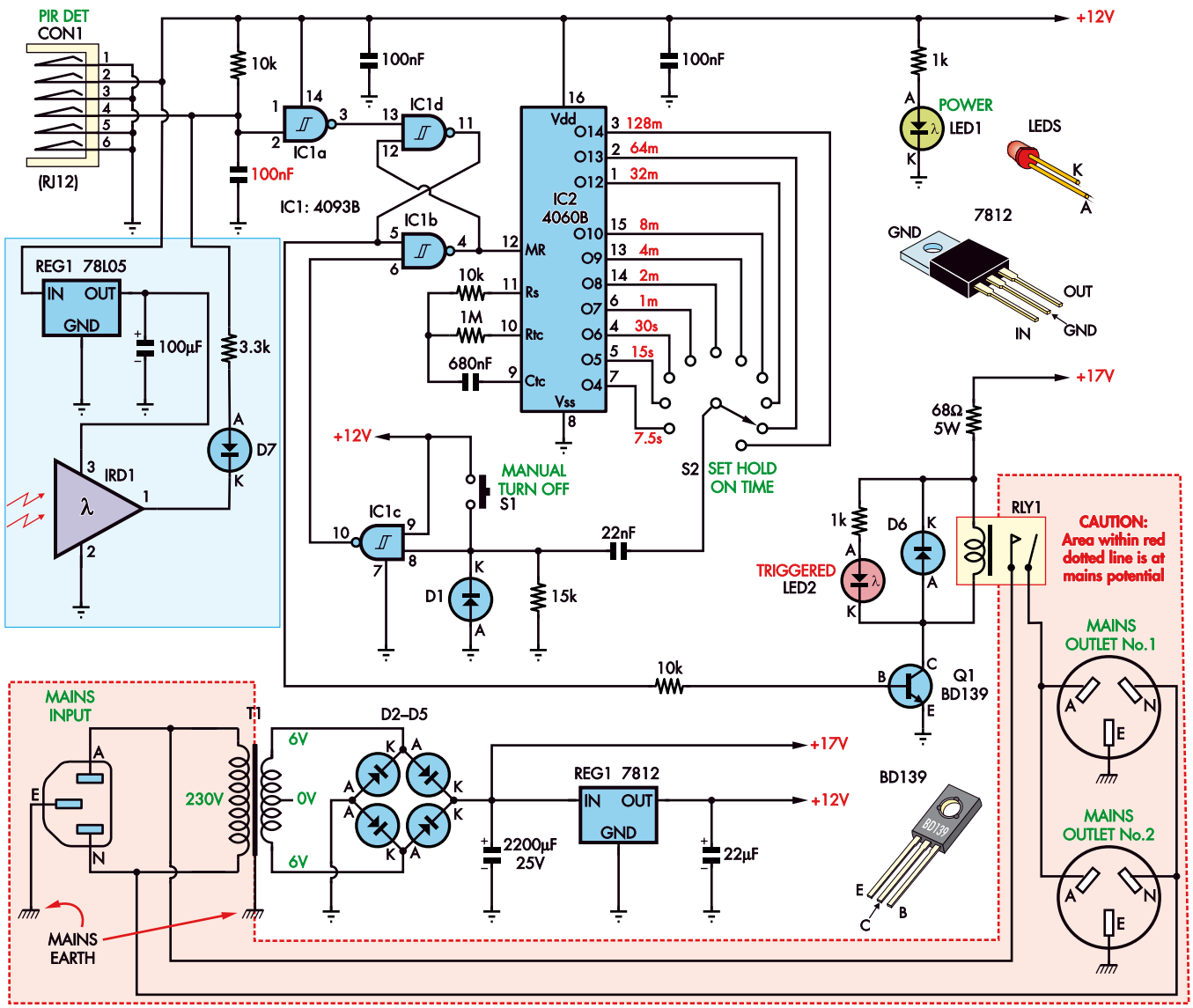
All you need to do then is power up the unit, plug in a mains load (a lamp will do), set it to a short delay (eg, 7.5 seconds), switch it on and check that the lamp goes off after the set time. Then point your TV remote at the IR receiver and hold down a button. Check that the lamp switches back on.

If it doesn't, you may need to lower the value of the 100nF capacitor shown in red on the circuit diagram.

That's because infrared receivers generate a short burst of pulses and it's possible that the RC filter formed by the added 3.3kΩ resistor and the 100nF capacitor could have a long enough time constant that the pulses are effectively filtered out. Try dropping it to 10nF and if that doesn't work, try 1nF.

Once it's working, you can then set the timeout to a more sensible value (32, 64 or 128 minutes) and plug your TV in. Happy snoozing!

Eric Richards,
Auckland, New Zealand ($55).



IR RECEIVER TRIGGERED MAINS TIMER

IPC Member

EMS Since 1999

LEACH

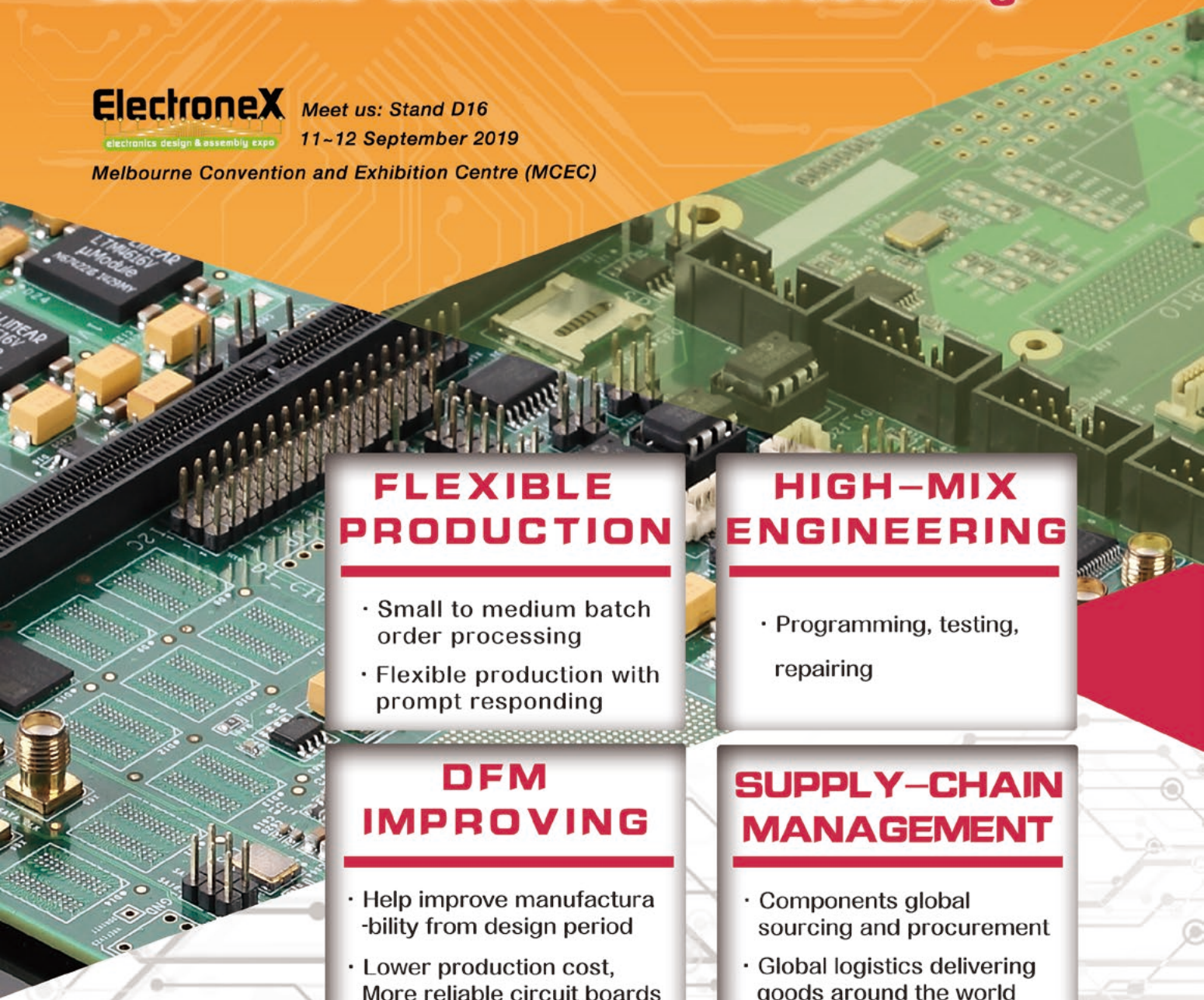
Reliable partner for electronic contract manufacturing

ElectroneX electronics design & assembly expo

Meet us: Stand D16

11~12 September 2019

Melbourne Convention and Exhibition Centre (MCEC)



FLEXIBLE PRODUCTION

- Small to medium batch order processing
- Flexible production with prompt responding

HIGH-MIX ENGINEERING

- Programming, testing, repairing

DFM IMPROVING

- Help improve manufactura -bility from design period
- Lower production cost, More reliable circuit boards

SUPPLY-CHAIN MANAGEMENT

- Components global sourcing and procurement
- Global logistics delivering goods around the world

LEACH (HK) Co., Ltd **Electronic Contract Manufacturing Turnkey Solution**

LEACH (SZ) Co., Ltd **info@leach-pcba.com** **www.leach-pcba.com**

USING A GEOPHONE WITH OUR ARDUINO SEISMOGRAPH

Our Arduino Seismograph from April 2018 uses a 3-axis MEMS accelerometer to measure the force of tremors and other vibrations. Typically seismographs will measure displacement, not force; but the good news is that you can measure it electronically using a "geophone" sensor.

by Tim Blythman

Reader Michael, from western NSW, kindly sent us a model 20DX geophone sensor, suggesting that this would be a great add-on to our seismograph project (siliconchip.com.au/Article/11030).

The geophone sensor is based around a sprung mass (a magnet) moving inside a coil. It generates a voltage proportional to the velocity of the magnet. This is different from the MEMS type sensors, which produce a value proportional to acceleration. While larger and heavier, the simple mechanical geophones are also much more sensitive than their MEMS counterparts.

The geophone sensor is marked with the code "10 395", meaning it has a nominal minimum frequency of 10Hz, and a coil resistance of 395Ω. Similar units are available from many online sellers. The unit we are using is designed for use in a vertical orientation, although units designed for horizontal use are also available.

Rather than building another seismograph from scratch, we decided to add the geophone sensor to our seismograph project. It records seismographic data as WAV files, which can be either manipulated and viewed with programs such as Audacity, or simply played back as audio.

The data from the geophone sensor is added as a fifth channel to the WAV data, complementing the existing Z-axis (vertical) channel, so all the data can be viewed together and compared.

Interfacing the geophone

As the output of the geophone sensor is just an analog voltage, we can read this using the Arduino's ADC (analog-to-digital converter). As it is an AC signal, we need to DC bias the signal to centre the sensor's zero-point in the ADC sample range.

To improve the resolution of the readings, instead of using the 5V supply rail as the ADC reference, we're using the micro's internal 1.1V reference. Because the potentiometer used to adjust sensitivity also uses the ADC, you need to add a series resistor to reduce its adjustment range to 0-1.1V.

16 ADC readings are taken from the geophone and averaged. The result is then fed through the same digital filter that is applied to the signals from the accelerometer.

Circuit description

The revised circuit is shown in Fig.1. A voltage divider comprising 51kΩ and 10kΩ resistors generates a ~0.55V rail for biasing the geophone. This is half of the nominally 1.1V ADC reference generated by the Arduino, so it allows the geophone output to swing over the full ADC range.

This biasing rail is filtered by a 220µF capacitor as the divider impedance is much higher than the geophone's, and otherwise, its frequency response would suffer. This capacitor also filters out any supply noise on the 3.3V rail. Any drift due to changes in the 3.3V supply voltage is rejected by a 0.5Hz software-defined high-pass filter.

We decided not to generate this reference rail by drawing current from the Arduino's AREF pin as that pin can source only a minimal amount of current.

VR2, connected across the geophone, dampens its output

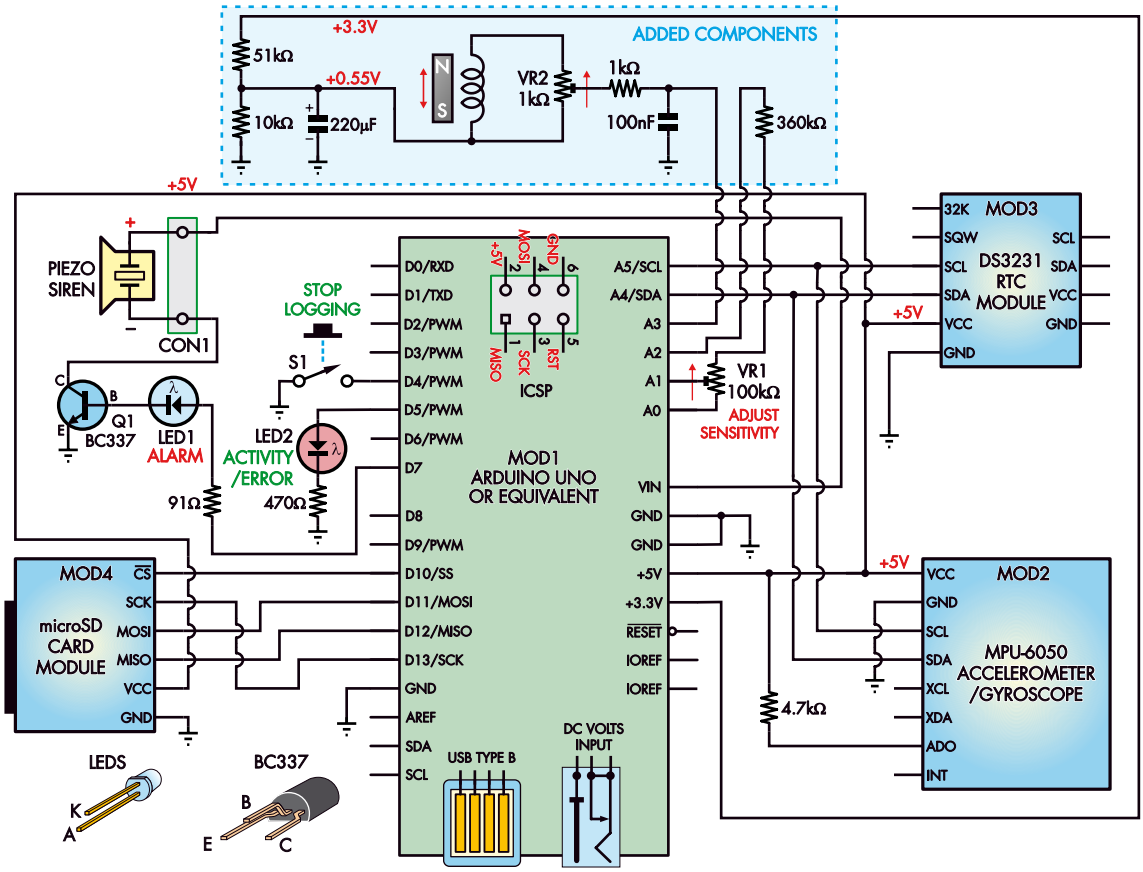


Fig.1: the additions to the existing Seismograph circuit are quite simple. The geophone is DC biased with a 0.55V rail generated by two resistors and one capacitor. It's loaded with a 1kΩ trimpot which also allows its sensitivity to be adjusted. The resulting signal then goes through an RC low-pass filter and into Arduino analog input pin A3.

ARDUINO 3-AXIS SEISMOGRAPH WITH GEOPHONE

to provide a flat frequency response (see Fig.2) and also allows its sensitivity to be adjusted, reducing the voltage fed to the Arduino's A3 analog input depending on its rotation.

Generally, we suggest you leave VR2 set fully clockwise, although you may need to back it off a bit if you're expecting to measure a large quake accurately.

The signal then goes through a low-pass filter with a -3dB point of 1.6kHz, made from a 1kΩ resistor and 100nF capacitor.

Further filtering is performed in the software. The 1kΩ series resistor also protects the Arduino from large (clipping) signals from the geophone, while the 100nF capacitor provides a low impedance for the ADC's sample-and-hold circuitry.

The 360kΩ resistor added in series with VR1 matches its range to the 1.1V internal reference instead of 5V, as before. We found that this provides more consistent geophone measurements than getting the ADC to switch between the two different reference voltages dynamically.

Construction

Since this is a simple circuit, we built it on stripboard. You will need a board with 15 rows, and at least six connected pads available in each row. If you have 18 rows, then the add-on board will neatly cover one side of an Arduino Uno Rev3 board. The component layout is shown in Fig.3. No track cuts are required.

We used a vertical (right-angle mounting) mini trimpot for VR2 in our prototype, but you can also use a horizontal trimpot, as shown in Fig.3

Five rows of stripboard are connected to the POWER section of the Arduino headers, and six rows go to the analog section. The empty row between these sections is used as our bias reference. The three extra rows below the analog section hold potentiometer VR2 and connect to the geophone sensor.

Due to the way the board is soldered to the Arduino headers, the components are fitted to the copper track side.

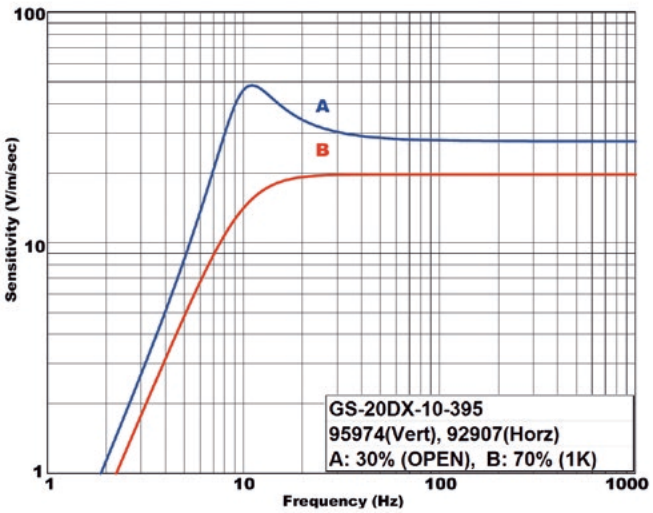


Fig.2: this frequency response graph from the 20DX datasheet shows how its normal response (A) is damped by resistive loading. The 1kΩ trimpot in our circuit gives us the relatively flat response shown by line B in red.

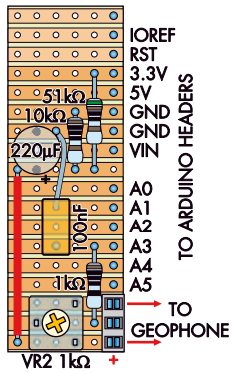


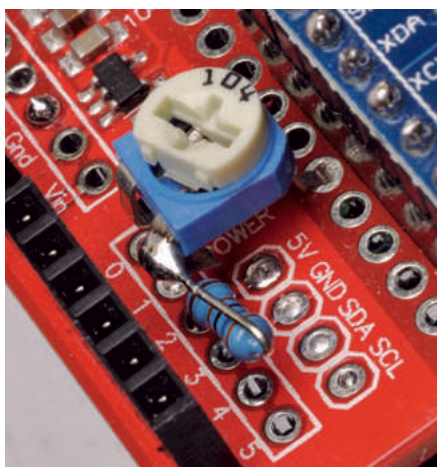
Fig.3: this circuit can easily be built on stripboard. Unusually, we're mounting most of the components on the copper side of the board. Make sure the component leads can't short to anything. The top three rows are optional.

So be careful when mounting them to ensure their leads can't short to any tracks or other component leads and mount the capacitors high enough that you can get your iron under them to solder the leads safely.

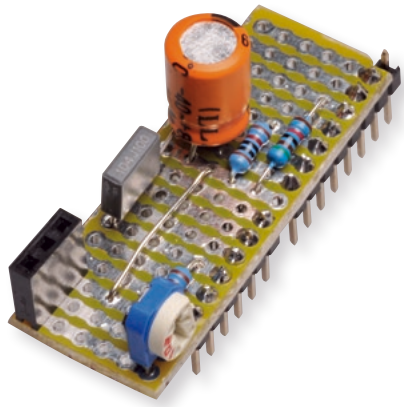
One wire link is needed (shown in red); we suggest that you use insulated Bell wire. Note how one lead of the 100nF MKT capacitor is soldered directly down into a hole in the A3 row, while the other lead is bent to go around the 220µF capacitor and connect to one of the GND rows.

We used a small 3-way female header strip and jumper wire off-cuts to connect the geophone sensor to the board. The + lead of the geophone sensor should connect to the end nearest the bottom edge of the board.

Finally, fit the 6-pin and 8-pin male headers to the underside, to connect to the Arduino. The easiest way to do this is to plug the headers into the sockets on the Arduino board or shield and then place the stripboard over the top and solder the pins. This ensures the two rows remain aligned.



The small change needed to the main shield. The 360kΩ resistor is soldered between the Arduino's A2 pin and where the trimpot was attached to A2. This allows the same trimpot setting to be used in spite of the change in voltage reference for the ADC peripheral.



You will also need to add the 360kΩ resistor to the trimpot on the original board. Detach the lead connected to A2, and fit the resistor between A2 and the trimpot lead.

We did this by cutting the trimpot pin and then desoldering the stub. You can now plug the stripboard 'shield' into the corresponding Arduino pins, wire up the geophone sensor, and you're ready to install the new software.

If you haven't already built the Arduino Seismograph, refer to the April 2018 article for instructions.

Revised software

The new software is very similar to that used in the April 2018 project. Some extra code has been added to set up the ADC reference voltage and to sample and record the extra channel.

The WAV header data has changed because there are now five channels rather than four. There is an extra line in setup() to set the 1.1V ADC reference, and extra code in loop() to sample, filter and output the new channel to the SD card.

We're assuming that you have already installed the Arduino IDE (integrated development environment). You can now download the revised sketch from our website, use the IDE to compile it and upload it to the Arduino board. The file is named "Arduino_Seismograph_with_Geophone.ino".

It's used in the same way as the original version. Insert an SD card into the slot and restart the Arduino board. Open the Arduino Serial Monitor at 115,200 baud to follow the program's progress and check for errors; you should see something similar to that shown in Screen 1.

If there are no errors, allow the sketch to run for a minute or so. You can emulate seismic activity by gently bumping the spot the seismograph is sitting on.

Press pushbutton S1 to stop logging and write the data to the SD card; there will be a message on the serial monitor when this has finished, and the indicator LED will light up continuously.

Remove the SD card and open the files with Audacity. You should see something similar to what we did, with five channels displayed. Any activity will show up as undulations in the traces (see Screen 2).

Here we can see movement on the two bottom channels, both of which are reading the Z axis. The bottommost channel is the geophone sensor, while the one above this is the MEMS accelerometer Z axis.

Based on the sensitivity of the geophone sensor with a 1kΩ damping resistor at around 20V per m/s, full-scale readings correspond to ±0.0275m/s. That's assuming that the attenuation trimpot is set to provide the maximum level. At any other setting, it will take faster motion to give full-scale readings.

In the April 2018 article, we mentioned that, with the default settings, the readings consume around 30MB of

Parts List

1 Arduino Seismograph unit (see April 2018 issue)
1 geophone sensor (20DX or similar)
1 piece of stripboard (at least 15 rows with at least six pads each)
1 5-pin male header ***or***
1 8-pin male header (with 18+ row stripboard)
1 6-pin male header
1 3-pin female header socket
1 short length of Bell wire
2 jumper leads to connect geophone sensor to header socket

Capacitors

1 220µF 6.3V electrolytic
1 100nF MKT polyester

Resistors (all 0.25W 1% metal film)

1 51kΩ 1 10kΩ 1 1kΩ 1 360kΩ
1 1kΩ mini trimpot (VR2)

SD card space per day. With the added channel in this version, that increases to around 38MB per day, or just over 1GB per month.

A simpler approach

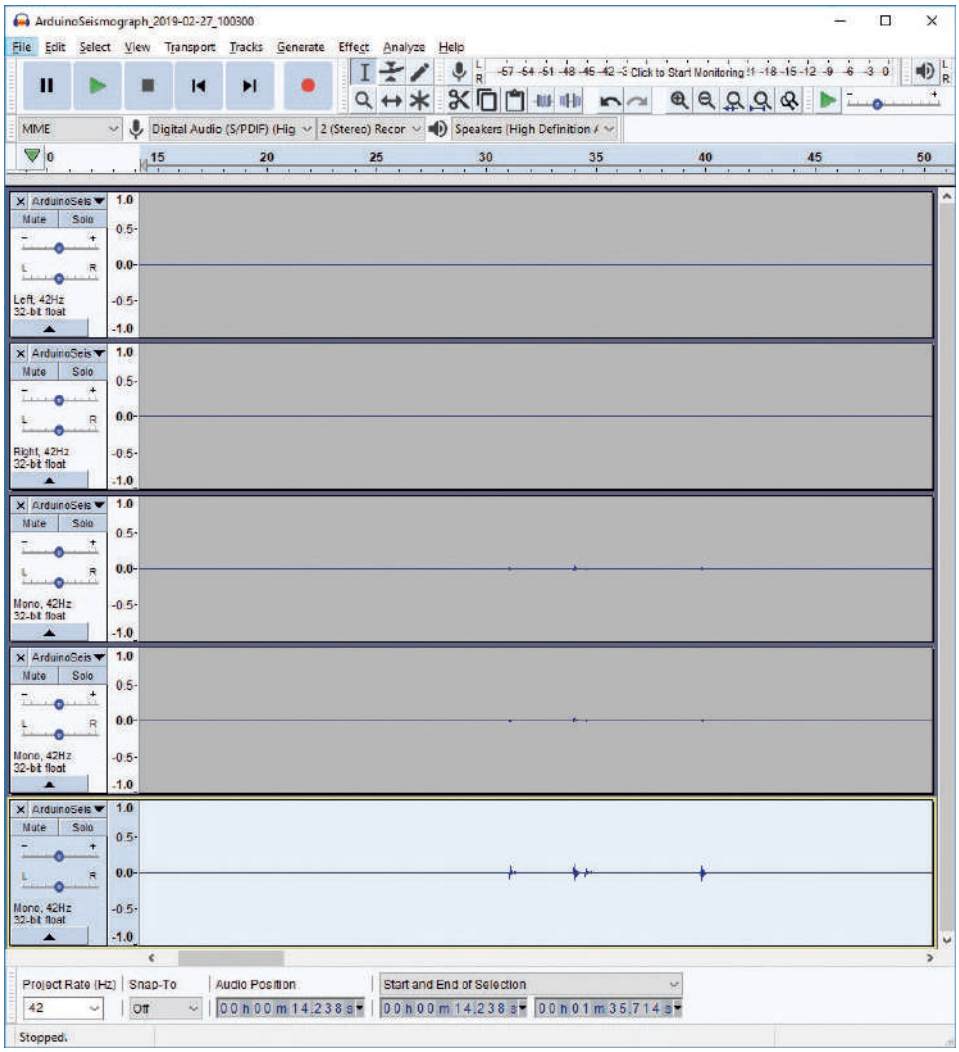
If you have a geophone sensor, but don't want to build the full Seismograph including the MEMS accelerometer, you could use the small stripboard circuit presented here with a bare Arduino Uno (or compatible) board and our test sketch. This sketch, named "Geophone_Sensor_Test.ino", was written so that we could test our geophone sensor in isolation.

Fit the stripboard interface to the Uno board and upload the test sketch. Open the Serial Plotter at 115,200 baud and you can view the output of the sensor in real-time. The vertical scale is merely the raw ADC data values, in the range 0-1023.

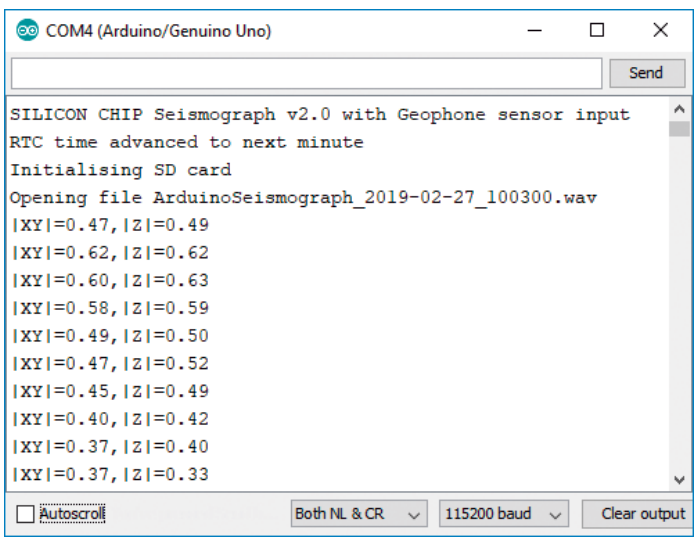
Mounting

As noted, the geophone sensor we used is designed for vertical mounting. Our tests involved placing the sensor on its flat end on a desk, and we found that it was quite sensitive like that.

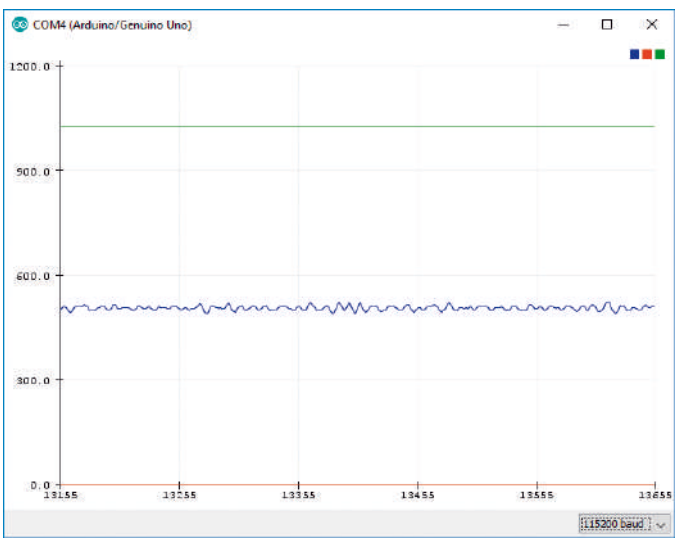
For the best performance in measuring seismic activity, the sensor should be rigidly attached to the underlying bedrock (or something else attached to it, like a concrete foundation). Many appear to use mechanical mounts such as bolts, but a good construction adhesive should make a reasonable substitute. SC



Screen 2: the seismograph writes data to the SD card as five-channel WAV files, which can be loaded with Audacity. Other audio editing software packages may not be able to handle five channels of audio in one file.



Screen 1: this sample Serial Monitor output is from the "Arduino_Seismograph_with_Geophone.ino" sketch immediately after power-up. If you get any error messages, check your wiring and the SD card.



Screen 3: we are sending the output of the "Geophone_ Sensor_Test.ino" sketch to the Serial Plotter. During this, the geophone sensor was being held by hand and did not appear to be moving much. So it really is quite sensitive.

VINTAGE RADIO

By Ian Batty

Healing 404B Aussie Compact

This set was picked up at an HRSA auction some time ago. It's an Australian-made, portable, 4-valve superhet from 1948.

Alfred George Healing started making bicycles in Bridge Road, Richmond, Victoria (Melbourne) in 1907. By the 1920s, radio sets represented the pinnacle of advancing technology and Healing Radio took on the challenge. They started manufacturing radios in 1922 and their famous "Golden Voice" brand was introduced in 1925.

At the same time, they imported and distributed Atwater Kent receivers from the UK, ceasing in 1930 as import tariffs increased. They worked out of premises at 167-173 Franklin St, Melbourne for some twenty years.

World War II saw Healing pitch in to build radar and other equipment for the armed forces. They then began manufacturing television sets in 1956. The brand still exists today although not as a TV set manufacturer.

The amazing shrinking radio

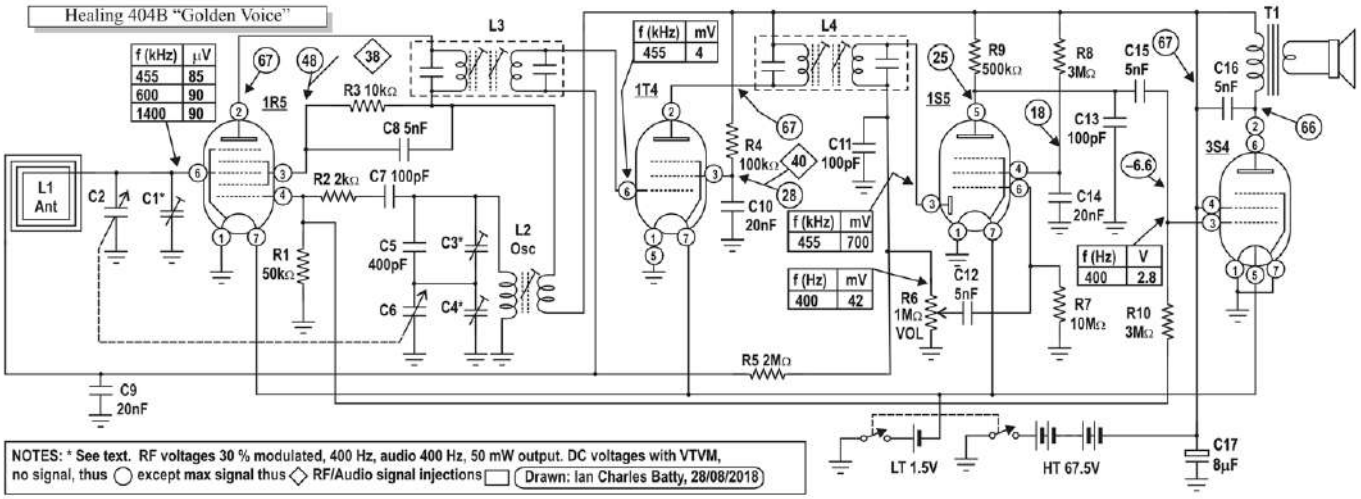
The design of the 404B portable follows RCA's landmark BP-10, one of the first sets using the new B7G all-glass miniature lineup of 1R5, 1T4, 1S5/1U5 and 1S4/3S4/3V4. These B7G valves, at under 25% of the volume of even the most compact octals, challenged designers to apply miniaturisation techniques elsewhere.

The speaker used in these miniaturised, portable sets was typically three to five inches in diameter. While buyers prized portability and convenience over fidelity, they would only accept so much "squawkiness" as a trade-off for size. Output transformers remained similar in size to older designs.

Without using solid dielectrics, tuning gangs could not shrink too much either. The volume of minor components stayed about the same, although IF transformers and coils could be shrunk.

The largest single components, the A and B batteries, became a limitation. The 1.5V LT supply could come from a single 950 ("D" size) cell. B7G valves work just fine with high tension supplies of at least 60V, so the logical choice was 67.5V – one-half of the old 135V HT battery.

This combination would only give some 3~5 hours of life for the LT cell against some 25-40 hours for the HT battery. Purchasers were advised of the discrepancy and warned to try replacing the LT cell before replacing the HT battery.



The original circuit for the Healing 404B, found in AORSM Vol.7 1948, is slightly different to this one. Instead of R10 connecting to pin 4 of V1 as shown above, R10 (2MΩ instead of 3MΩ) was wired in series with a 900Ω resistor which formed a resistive divider with the negative end of the HT supply. The padder (C3-C4) is not used in all 404Bs; when not present, the oscillator trimmer is mounted under the coil. The wire trimmer C1 is also not always included.

Some other manufacturers of these compact sets used a pair of 950 cells, doubling the "A" supply lifetime.

The Healing 404B

RCA's engineers offered one major innovation in the BP-10: a loop antenna hidden in the hinged lid. This freed the antenna from the capacitive and inductive effects of other components in the case. Opening the lid also activated the power switch.

In practice, the set could be stood up in any position for the best sound, then the loop re-positioned for the best signal by adjusting the door's angle.

The Healing 404B uses a similar design. It's a conventionally constructed valve set, using valve sockets and point-to-point wiring mounted onto a pressed-and-punched steel chassis. There's just one tag strip.

Healing's engineers did a good job of keeping the radio compact and portable but they failed on a key factor in all equipment design – maintainability.

The 404B is so compact that IF alignment is difficult. Not only are two out of four brass adjusting screws inaccessible but the adjusting flats on the two that are exposed have been snipped off! Fortunately, IF alignments don't drift much and swapping valves rarely demands a complete re-alignment.

The set uses cotton-jacketed multistrand wire, some of which vanishes in the maze of components. The valve sockets are also well buried, making voltage readings difficult. Although I like this set for its convenience and performance, it's not one I'd want to work on too often.

The construction quality is acceptable without being noteworthy.

Circuit description

The design appears to be an evolution of the RCA BP-10 circuit but the 404B omits the BP-10's back bias circuitry for the output stage, instead picking off a negative voltage from the 1R5 converter grid.

The signal from the loop antenna connects directly to the 1R5's grid. The loop is tuned by one half of the 12-375pF ganged tuning capacitor. There is a wire trimmer (C1, typically a fixed 4pF capacitor) but the alignment notes advise against adjusting this. See the references below for more details on this and on the local oscillator (LO) circuit operation.

The 1R5 converter's local oscillator uses the screen grids (internally-connected grids 2 and 4) and the valve's anode as the oscillator anode.

This is common with the 1R5, as it lacks a dedicated oscillator anode element. The common alternatives are either to use just the G2/G4 connection or to put the oscillator coil's primary in the filament lead and use an RF choke for the connection to the filament supply.

No space wasted

As the tuning gang has two identical 12-375pF sections, a padder is needed. This part of the circuit was modified over various versions of the set, so you may find that yours does not match the circuit shown in this article.

The 1R5 screen connects to the "cold" end of the IF primary via dropping resistor R3 and bypass capacitor C8, with its anode connected to the other end of the IF primary. These two connections then meet the "hot" end of the oscillator coil's primary, using screens and signal anode as the oscillator anode.

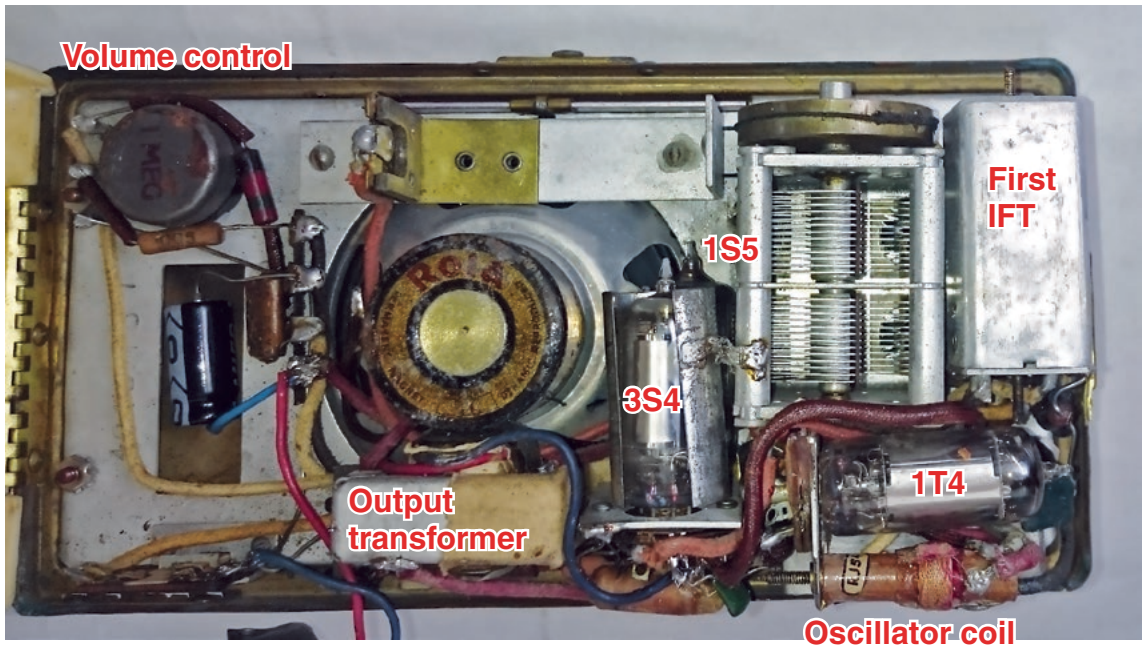
Valve local oscillators work in Class C, where the grid is driven into conduction during the positive peak of the operating cycle, with current cut off at the opposite peak.

Driving the grid positive forces it into rectification, establishing an overall negative bias on the valve. It's usually negative by a few volts; enough to pick off as bias for the 3S4 output valve.

Bias for the output stage does rely on a fairly constant LO grid current to generate a constant grid bias, and low (or no) LO activity will reduce or eliminate output stage bias. I found that the bias voltage varied from around -5V to -6V as the set was tuned from its low end to the high end.

This bias is developed across the LO grid resistor R1 (50kΩ), with grid stopper R2 (2kΩ) in place to give more constant LO activity and (hence) a more constant output valve bias.

The first IF transformer has a tuned, untapped primary and secondary. The secondary feeds the 1T4 IF amplifier. You'll see this type of valve used with full HT on the screen or (as in this set) supplied via a bypassed dropping resistor, in this case, R4 (100kΩ) with a 20nF bypass capacitor (C10).



Converter V1 (1R5) is located directly behind the first IF transformer, while the second IF transformer is behind IF amplifier V2 (1T4). The padder is located behind the oscillator coil, and the hard-to-see 1S5 (V3) pokes out from behind the 3S4 (V4).

Reducing screen voltage on a pentode/tetrode reduces gain, and it's common in highly compact sets (and those with two IF stages) to "starve" the screen to prevent IF oscillation from unnecessarily high gain.

The output signal from the second IF stage goes to the 1S5's demodulator diode. This supplies demodulated audio (via 5nF capacitor C12) to 1MΩ volume control potentiometer R6.

The DC component of this signal is used for AGC and this is fed via a 2MΩ resistor (R5) and 20nF smoothing capacitor (C9) back to the control grid of the IF amplifier (via the first IF secondary) and then to the converter via the loop antenna.

Audio from the volume control goes (via 5nF capacitor C12) to the control grid of the 1S5 pentode section. This gets "contact potential" bias via 10MΩ resistor R7.

The circuit around the 1S5 is optimised for voltage gain; it hits the sweet spot between low anode and screen current (which both reduce voltage gain) and a high-value anode load resistor (which gives a high gain). In practice, you can expect a voltage gain of some 40-55 times. This circuit uses a 500kΩ anode load (R9) and 3MΩ screen dropping resistor (R8).

The 1S5 anode is bypassed to ground for intermediate frequencies by 100pF capacitor C13 and its screen is bypassed to ground for audio by 20nF capacitor C14.

Audio from the 1S5 is fed, via 5nF capacitor C15, to the 3S4 output stage's signal grid. This is DC biased to about -6V via 3MΩ resistor R10 and the aforementioned negative bias from the 1R5 oscillator grid.

The output stage drives a 5kΩ speaker transformer, which is bypassed by 5nF capacitor C16. This acts to damp the output transformer's natural primary resonance. It also reduces the set's high-frequency response. Some manufacturers connect the "cold" end of these capacitors to ground but that's a recipe for disaster.

Should this capacitor become shorted, the full HT voltage appears across the output transformer's primary winding. While this set's HT battery may not be able to deliver enough current to burn out the transformer, it can certainly happen in a mains-powered set. It's better to connect the "cold" end of the capacitor to HT, as done in the 404B.

The 3S4 output valve in this set has an external metal shield, which at first glance seems odd. You'd expect to see a shield in the RF/IF section but not at the audio end. But this set's highly compact design made it vulnerable to audio feedback and the shield prevents the output's anode from radiating back to the audio input section.

Although I find it didn't cause any problems if I removed it, I've left it in place in my set for safety reasons.

The Healing 404B uses a small A battery to supply the 1.5V heaters and a larger B battery for the 67.5V HT.

Cleaning it up

The set was in good cosmetic condition when I bought it, with minor ageing on some of the metal parts. Elec-

trically, it had seen one repair: audio coupling capacitor C15 had been replaced with a polyester "greencap".

Preliminary testing showed that the audio response dived at about 700Hz. Closer examination showed C16 to be a 10nF capacitor connected from the 3S4 anode to ground.

Puzzlingly, this appeared to be an original component. Aside from the non-recommended connection method, the value was twice that shown in the diagram and this had a major effect on the high-frequency cutoff point.

The IF bandwidth test (detailed below) indicated a potential response considerably better than a measly 700Hz. Replacing C16 with the recommended 4.7nF value improved the top end to 1.2kHz, as expected. I replaced leaky HT bypass capacitor C17 (8µF) at the same time.

How good is it?

My trusty ferrite rod radiating antenna required careful orientation with its axis perpendicular to the plane of the loop for good results.

Air sensitivity results appear "about right" for this kind of set. I'm offering these readings for comparative and fault-finding use; my readings may not represent the set's true air sensitivity.

Under my test conditions and for a standard 50mW output, the 404B needs around 160µV/m at 600kHz and 110µV/m at 1400kHz. The signal-to-noise ratios exceeded 20dB in both cases.

RF Bandwidth is around ±1.2kHz at -3dB; at -60dB, it's ±23kHz. AGC action is only fair; a 20dB input signal increase gave an output rise of 6dB. Audio response is 90Hz-2.4kHz from volume control to speaker; from antenna to speaker it's 90Hz-1.2kHz.

The set's audio output is about 85mW at clipping, with 10% THD (total harmonic distortion). At 50mW, THD is around 6%; at 10mW, it's about 3.5%.

The set's loop antenna is directional, with the hinged lid making it easy to orientate for maximum pickup. Testing on-air, it was able to pull in my reference 3WV over in Western Victoria with ease.

Low-battery performance

It's often said that the weakest valve in the set is the converter; it'll stop at the top (or bottom!) end of the band, won't start with low supply voltages, only works in months containing the letter "r" and so on. This was certainly true with the first 2V battery-powered pentagrid valve, the 1A6.

So, I tested this set with a good 1R5. I found that the converter worked with a filament supply voltage as low as 1.0V. Reception was weak but reliable, so I dropped the HT voltage. I could still get some reception with only 45V HT and 1.0V for the filament supply.

So while it's true that the converter is the most critical stage in a superhet, don't automatically start "valve-jockeying" converters in the hopes of fixing a set until you've done some proper testing.

Conclusion

This is a nice set, but I have an RCA BP-10 sitting on the shelf waiting for an outing. It'll be interesting to see how well the 'original' performs against one of its 'descendants'.

There's a lot more information on the 404B on Kevin Chant's website, at www.kevinchant.com/healing2.html

Also see Ernst Erb's Radio Museum: www.radiomuseum.org/r/healing_404b.html

For more information on Healing's radio models, see: www.hws.org.au/RadioHistory/manufacturers/Healing.htm

SC

The Healing 404B was sold for £20 (including batteries), with cream being the only available colour.

SILICON CHIP.com.au/shop ONLINESHOP

Looking for a specialised component to build that latest and greatest Silicon Chip project? Maybe it's the PCB you're after? Or a pre-programmed micro? Or some other hard-to-get "bit"? The chances are they are available direct from the Silicon Chip Online Shop.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, irregardless of how many items you order! (AUS only; overseas clients – check the website for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, subscribers receive a 10% discount on purchases! (Excluding subscription renewals and postage costs)

HERE'S HOW TO ORDER:

VISA MasterCard PayPal

All prices are in AUSTRALIAN DOLLARS ($AUD)

✔ **INTERNET** (24 hours, 7 days): Log on to our secure website – siliconchip.com.au, click on "SHOP" and follow the links

✔ **EMAIL** (24 hours, 7 days): email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details

✔ **MAIL** (24 hours, 7 days): PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details

✔ **PHONE** (9am-5pm AET, Mon-Fri): Call (02) 9939 3295 (INT +612 9939 3295) – have your order ready, including contact and payment details!

YES! You can also order or renew your Silicon Chip subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Micros cost from $10.00 to $20.00 each + $10 p&p per order#

$10 MICROS

ATtiny816	ATtiny816 Development/Breakout Board (Jan19)
PIC12F617-I/P	Temperature Switch Mk2 (June18), Recurring Event Reminder (Jul18) Door Alarm (Aug18), Steam Whistle (Sept18) White Noise / Insomnia Killer (Sept18 / Nov18), Remote Control Dimmer (Feb19)
PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10) Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12), Do Not Disturb (May13) IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies *2 chips – $15 pair* (Aug13), Driveway Monitor Receiver (July15) Hotel Safe Alarm (Jun16), 50A Battery Charger Controller (Nov16) Kelvin the Cricket (Oct17), Triac-based Mains Motor Speed Controller (Mar18) Heater Controller (Apr18), Useless Box IC3 (Dec18)
PIC12F675-E/P	Courtesy LED Light Delay for Cars (Oct14), Fan Speed Controller (Jan18)
PIC16F1455-I/P	Microbridge (May17), USB Flexitimer (June18), Digital Interface Module (Nov18)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13) Auto Headlight Controller (Oct13), 10A 230V Motor Speed Controller (Feb14) Automotive Sensor Modifier (Dec16)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11) Quizzical (Oct11), Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13) Nicad/NiMH Burp Charger (Mar14), Remote Mains Timer (Nov14) Driveway Monitor Transmitter (July15), Fingerprint Scanner (Nov15) MPPT Lighting Charge Controller (Feb16), 50/60Hz Turntable Driver (May16) Cyclic Pump Timer (Sep16), 60V 40A DC Motor Speed Controller (Jan17) Pool Lap Counter (Mar17), Rapidbrake (Jul17), Deluxe Frequency Switch (May18) Useless Box IC1 (Dec18), Remote-controlled Preamp with Tone Control (Mar19)
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13), GPS Analog Clock Driver (Feb17)

$15 MICROS

PIC16F1459-I/SO	Four-Channel DC Fan & Pump Controller (Dec18)
PIC16F84A-20I/P	Programmable Ignition Timing Module (Jun99), Fuel Mixture Display (Sept00) Oscar Naughts And Crosses (Oct07), UV Lightbox Timer (Nov07)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), 16-bit Digital Pot (Jul10), Semtest (Feb-May12)
PIC16F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F4550-I/P	Multi-Purpose Car Scrolling Display (Dec08), GPS Car Computer (Jan10)
PIC32MM0256GPM028-I/SS	Super Digital Sound Effects (Aug18)
PIC32MX170F256B-50I/SP	Micromite Mk2 (Jan15) + ***47µF***, Low Frequency Distortion Analyser (Apr15) Micromite LCD BackPack [either version] (Feb16), GPS Boat Computer (Apr16) Micromite Super Clock (Jul16), Touchscreen Voltage/Current Ref (Oct-Dec16) Micromite LCD BackPack V2 (May17), Deluxe eFuse (Aug17) Micromite DDS for IF Alignment (Sept17), Tariff Clock (Jul18) GPS-Synched Frequency Reference (Nov18)
PIC32MX270F256B-50I/SP	ASCII Video Terminal (Jul14), USB Mouse & Keyboard Adaptor (Feb19)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12) Touchscreen Audio Recorder (Jun/Jul 14)
dsPIC33FJ64MC802-E/SP	Induction Motor Speed Controller (revised) (Aug13)

$20 MICROS

PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14) Digital Effects Unit (Oct14)
PIC32MX470F512H-120/PT	Micromite PLUS Explore 64 (Aug 16), Micromite Plus LCD BackPack (Nov16)
PIC32MX470F512L-120/PT	Micromite PLUS Explore 100 (Sep-Oct16)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Cont. (Oct-Dec10) SportSync (May11), Digital Audio Delay (Dec11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)

When ordering, be sure to select BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, HARD-TO-GET BITS, ETC

P&P – $10 Per order#

TOUCH & IR REMOTE CONTROL DIMMER *(FEB 19)*
- N-channel Mosfets Q1 & Q2 (SIHB15N60E) and two 4.7MΩ 3.5kV resistors **$20.00**
- IRD1 (TSOP4136) and fresnel lens (IML0688) **$10.00**

MOTION SENSING SWITCH (SMD VERSION) *(FEB 19)*
- Short form kit (includes PCB and all parts, except for the extension cable) **$10.00**
- SW-18010P vibration sensor (S1) **$1.00**

DAB+/FM/AM RADIO *(JAN 19)*
- main PCB with IC1 pre-soldered **$60.00**
- main PCB with IC1 and surrounding components (in box at top right) pre-soldered **$90.00**
- Explore 100 kit (Cat SC3834; no LCD included) **$69.90**
- laser-cut clear acrylic case pieces **$20.00**
- set of extra SMD parts (contains most SMD parts except for the digital audio output) **$30.00**
- extendable VHF whip antenna with SMA connector: 700mm (**$15.00**) and 465mm (**$10.00**)
- PCB-mounting SMA (**$2.50**), PAL (**$5.00**) and dual-horizontal RCA (**$2.50**) socket

DIGITAL INTERFACE MODULE KIT (CAT SC4750) *(NOV 18)*
- Includes PCB, programmed micro and all other required onboard components **$15.00**

TINNITUS/INSOMNIA KILLER HARD-TO-GET PARTS (CAT SC4792) *(NOV 18)*
- One LF50CV regulator (TO-220) and LM4865MX audio amplifier IC (SOIC-8) **$10.00**

GPS-SYNCHED FREQUENCY REFERENCE SMD PARTS (CAT SC4762) *(NOV 18)*
- Includes PCB and all SMD parts required **$80.00**

SUPER DIGITAL SOUND EFFECTS KIT (CAT SC4658) *(AUG 18)*
- PCB and all onboard parts (including optional ones) but no SD card, cell or battery holder **$40.00**

RECURRING EVENT REMINDER PCB+PIC BUNDLE (CAT SC4641) *(JUL 18)*
- PCB and programmed micro for a discount price **$15.00**

USB PORT PROTECTOR COMPLETE KIT (CAT SC4574) *(MAY 18)*
- All parts including the PCB and a length of clear heatshrink tubing **$15.00**

PARTS FOR THE 6GHz+ TOUCHSCREEN FREQUENCY COUNTER *(OCT 17)*
- Explore 100 kit (Cat SC3834; no LCD included) **$69.90**
- one ERA-2SM+ & one ADCH-80A+ (Cat SC1167; **two required**) **$15.00/pk.**

MICROBRIDGE COMPLETE KIT (CAT SC4264) *(MAY 17)*
- PCB plus all on-board parts including programmed microcontroller (SMD ceramics for 10µF) **$20.00**

MICROMITE LCD BACKPACK V2 – COMPLETE KIT (CAT SC4237) *(MAY 17)*
- includes PCB, programmed micro, touchscreen LCD, laser-cut UB3 lid, mounting hardware, SMD Mosfets for PWM backlight control and all other on-board parts **$70.00**

SC200 AMPLIFIER MODULE (CAT SC4140) *(JAN 17)*
- hard-to-get parts: Q8-Q16, D2-D4, 150pF/250V capacitor and five SMD resistors **$35.00**

VARIOUS MODULES & PARTS
- MCP1700 3.3V LDO regulator (suitable for USB Mouse & Keyboard Adapator, FEB19) **$1.50**
- LM4865MX amplifier IC & LF50CV regulator (Tinnitus/Insomnia Killer, NOV18) **$10.00**
- 2.8-inch touchscreen LCD module with SD card socket (Tide Clock, JUL18) **$22.50**
- ESP-01 WiFi Module (El Cheapo Modules, Part 15, APR18) **$5.00**
- MC1496P double-balanced mixer IC (DIP-14) (AM Radio Transmitter, MAR18) **$2.50**
- WiFi Antennas with U.FL/IPX connectors (Water Tank Level Meter with WiFi, FEB18):
  - 5dBi – **$12.50** ~ 2dBi (omnidirectional) – **$10.00**
- NRF24L01+PA+NA transceiver with SNA connector and antenna (El Cheapo 12, JAN18) **$5.00**
- WeMos D1 Arduino-compatible boards with WiFi (SEPT17, FEB18):
  - ThingSpeak data logger – **$10.00** ~ WiFi Tank Level Meter (ext. antenna socket) – **$15.00**
- Geeetech Arduino MP3 shield (Arduino Music Player/Recorder, VS1053, JUL17) **$20.00**
- 1nF 1% MKP (5mm lead spacing) or ceramic capacitor (Wide-Range LC Meter, JUN18) **$2.50**
- MAX7219 LED controller boards (El Cheapo Modules, Part 7, JUN17):
  - 8x8 red SMD/DIP matrix display – **$5.00** ~ red 8-digit 7-segment display – **$7.50**
- AD9833 DDS module (with gain control) (for Micromite DDS, APR17) **$25.00**
- AD9833 DDS module (no gain control) (El Cheapo Modules, Part 6, APR17) **$15.00**
- CP2102 USB-UART bridge **$5.00**
- microSD card adaptor (El Cheapo Modules, Part 3, JAN17) **$2.50**
- DS3231 real-time clock with mounting spacers and screws (El Cheapo, Part 1, OCT16) **$5.00**

THESE ARE ONLY THE MOST RECENT MICROS AND SPECIALISED COMPONENTS. FOR THE FULL LIST, SEE www.siliconchip.com.au/shop

*Prices valid for month of magazine issue only. All prices in Australian dollars and include GST where applicable. **# P&P prices are within Australia. O'seas? Place an order on our website for an accurate quote.**

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB ONLY. If you want a kit, check our store or contact the kit suppliers advertising in this issue. For unusual projects where kits are not available, some have specialised components available – see the list opposite.

NOTE: Not all PCBs are shown here due to space limits but the SILICON CHIP Online Shop has boards going back to 2001 and beyond. For a complete list of available PCBs etc, go to *siliconchip.com.au/shop/8* Prices are PCBs only, NOT COMPLETE KITS!

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10.00/set
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30.00/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	SC2892	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7.50
DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50
VOLTAGE/RESISTANCE/CURRENT REFERENCE	AUG 2015	04108151	$2.50
LED PARTY STROBE MK2	AUG 2015	16101141	$7.50
ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	15108151	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$10.00
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$15.00
TURNTABLE STROBE	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE LIGHT SPEEDUP	JAN 2016	05102161	$15.00
SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB/MAR 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB/MAR 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB/MAR 2016	07102122	$7.50
BATTERY CELL BALANCER	MAR 2016	11111151	$6.00
DELTA THROTTLE TIMER	MAR 2016	05102161	$15.00
MICROWAVE LEAKAGE DETECTOR	APR 2016	04103161	$5.00
FRIDGE/FREEZER ALARM	APR 2016	03104161	$5.00
ARDUINO MULTIFUNCTION MEASUREMENT	APR 2016	04116011/2	$15.00
PRECISION 50/60Hz TURNTABLE DRIVER	MAY 2016	04104161	$15.00
RASPBERRY PI TEMP SENSOR EXPANSION	MAY 2016	24104161	$5.00
100DB STEREO AUDIO LEVEL/VU METER	JUN 2016	01104161	$15.00
HOTEL SAFE ALARM	JUN 2016	03106161	$5.00
UNIVERSAL TEMPERATURE ALARM	JULY 2016	03105161	$5.00
BROWNOUT PROTECTOR MK2	JULY 2016	10107161	$10.00
8-DIGIT FREQUENCY METER	AUG 2016	04105161	$10.00
APPLIANCE ENERGY METER	AUG 2016	04116061	$15.00
MICROMITE PLUS EXPLORE 64	AUG 2016	07108161	$5.00
CYCLIC PUMP/MAINS TIMER	SEPT 2016	10108161/2	$10.00/pair
MICROMITE PLUS EXPLORE 100 (4 layer)	SEPT 2016	07109161	$20.00
AUTOMOTIVE FAULT DETECTOR	SEPT 2016	05109161	$10.00
MOSQUITO LURE	OCT 2016	25110161	$5.00
MICROPOWER LED FLASHER	OCT 2016	16109161	$5.00
MINI MICROPOWER LED FLASHER	OCT 2016	16109162	$2.50
50A BATTERY CHARGER CONTROLLER	NOV 2016	11111161	$10.00
PASSIVE LINE TO PHONO INPUT CONVERTER	NOV 2016	01111161	$5.00
MICROMITE PLUS LCD BACKPACK	NOV 2016	07110161	$7.50
AUTOMOTIVE SENSOR MODIFIER	DEC 2016	05111161	$10.00
TOUCHSCREEN VOLTAGE/CURRENT REFERENCE	DEC 2016	04110161	$12.50
SC200 AMPLIFIER MODULE	JAN 2017	01108161	$10.00
60V 40A DC MOTOR SPEED CON. CONTROL BOARD	JAN 2017	11112161	$10.00
60V 40A DC MOTOR SPEED CON. MOSFET BOARD	JAN 2017	11112162	$12.50
GPS SYNCHRONISED ANALOG CLOCK	FEB 2017	04202171	$10.00
ULTRA LOW VOLTAGE LED FLASHER	FEB 2017	16110161	$2.50
POOL LAP COUNTER	MAR 2017	19102171	$15.00
STATIONMASTER TRAIN CONTROLLER	MAR 2017	09103171/2	$15.00/set
EFUSE	APR 2017	04102171	$7.50
SPRING REVERB	APR 2017	01104171	$12.50
6GHz+ 1000:1 PRESCALER	MAY 2017	04112162	$7.50
MICROBRIDGE	MAY 2017	24104171	$2.50
MICROMITE LCD BACKPACK V2	MAY 2017	07104171	$7.50
10-OCTAVE STEREO GRAPHIC EQUALISER PCB	JUN 2017	01105171	$12.50
10-OCTAVE STEREO GRAPHIC EQUALISER FRONT PANEL	JUN 2017	01105172	$15.00
10-OCTAVE STEREO GRAPHIC EQUALISER CASE PIECES	JUN 2017	SC4281	$15.00
RAPIDBRAKE	JUL 2017	05105171	$10.00
DELUXE EFUSE	AUG 2017	18106171	$15.00
DELUXE EFUSE UB1 LID	AUG 2017	SC4316	$5.00
MAINS SUPPLY FOR BATTERY VALVES (INC. PANELS)	AUG 2017	18108171-4	$25.00
3-WAY ADJUSTABLE ACTIVE CROSSOVER	SEPT 2017	01108171	$20.00
3-WAY ADJUSTABLE ACTIVE CROSSOVER PANELS	SEPT 2017	01108172/3	$20.00/pair
3-WAY ADJUSTABLE ACTIVE CROSSOVER CASE PIECES	SEPT 2017	SC4403	$10.00
6GHz+ TOUCHSCREEN FREQUENCY COUNTER	OCT 2017	04110171	$10.00
KELVIN THE CRICKET	OCT 2017	08109171	$10.00
6GHz+ FREQUENCY COUNTER CASE PIECES (SET)	DEC 2017	SC4444	$15.00
SUPER-7 SUPERHET AM RADIO PCB	DEC 2017	06111171	$25.00
SUPER-7 SUPERHET AM RADIO CASE PIECES	DEC 2017	SC4464	$25.00
THEREMIN	JAN 2018	23112171	$12.50
PROPORTIONAL FAN SPEED CONTROLLER	JAN 2018	05111171	$2.50
WATER TANK LEVEL METER (INCLUDING HEADERS)	FEB 2018	21110171	$7.50
10-LED BARAGRAPH	FEB 2018	04101181	$7.50
10-LED BARAGRAPH SIGNAL PROCESSING	FEB 2018	04101182	$5.00
TRIAC-BASED MAINS MOTOR SPEED CONTROLLER	MAR 2018	10102181	$10.00
VINTAGE TV A/V MODULATOR	MAR 2018	02104181	$7.50
AM RADIO TRANSMITTER	MAR 2018	06101181	$7.50
HEATER CONTROLLER	APR 2018	10104181	$10.00
DELUXE FREQUENCY SWITCH	MAY 2018	05104181	$7.50
USB PORT PROTECTOR	MAY 2018	07105181	$2.50
2 x 12V BATTERY BALANCER	MAY 2018	14106181	$2.50
USB FLEXITIMER	JUNE 2018	19106181	$7.50
WIDE-RANGE LC METER	JUNE 2018	04106181	$5.00
WIDE-RANGE LC METER (INCLUDING HEADERS)	JUNE 2018	SC4618	$7.50
WIDE-RANGE LC METER CLEAR CASE PIECES	JUNE 2018	SC4609	$7.50
TEMPERATURE SWITCH MK2	JUNE 2018	05105181	$7.50
LiFePO4 UPS CONTROL SHIELD	JUNE 2018	11106181	$5.00
RASPBERRY PI TOUCHSCREEN ADAPTOR (TIDE CLOCK)	JULY 2018	24108181	$5.00
RECURRING EVENT REMINDER	JULY 2018	19107181	$5.00
BRAINWAVE MONITOR (EEG)	AUG 2018	25107181	$10.00
SUPER DIGITAL SOUND EFFECTS	AUG 2018	01107181	$2.50
DOOR ALARM	AUG 2018	03107181	$5.00
STEAM WHISTLE / DIESEL HORN	SEPT 2018	09106181	$5.00
DCC PROGRAMMER	OCT 2018	09107181	$5.00
DCC PROGRAMMER (INCLUDING HEADERS)	OCT 2018	09107181	$7.50
OPTO-ISOLATED RELAY (WITH EXTENSION BOARDS)	OCT 2018	10107181/2	$7.50
GPS-SYNCHED FREQUENCY REFERENCE	NOV 2018	04107181	$7.50
LED CHRISTMAS TREE	NOV 2018	16107181	$5.00
DIGITAL INTERFACE MODULE	NOV 2018	16107182	$2.50
TINNITUS/INSOMNIA KILLER (JAYCAR VERSION)	NOV 2018	01110181	$5.00
TINNITUS/INSOMNIA KILLER (ALTRONICS VERSION)	NOV 2018	01110182	$5.00
HIGH-SENSITIVITY MAGNETOMETER	DEC 2018	04101011	$12.50
USELESS BOX	DEC 2018	08111181	$7.50
FOUR-CHANNEL DC FAN & PUMP CONTROLLER	DEC 2018	05108181	$5.00
ATtiny816 DEVELOPMENT/BREAKOUT BOARD	JAN 2019	24110181	$5.00
ISOLATED SERIAL LINK	JAN 2019	24107181	$5.00
DAB+/FM/AM RADIO	JAN 2019	06112181	$15.00
TOUCH & IR REMOTE CONTROL DIMMER MAIN PCB	FEB 2019	10111191	$10.00
REMOTE CONTROL DIMMER MOUNTING PLATE	FEB 2019	10111192	$10.00
REMOTE CONTROL DIMMER EXTENSION PCB	FEB 2019	10111193	$10.00
MOTION SENSING SWITCH (SMD) PCB	FEB 2019	05102191	$2.50
USB MOUSE AND KEYBOARD ADAPTOR PCB	FEB 2019	24311181	$5.00
REMOTE-CONTROLLED PREAMP WITH TONE CONTROL	MAR 2019	01111119	$25.00
PREAMP INPUT SELECTOR BOARD	MAR 2019	01111112	$15.00
PREAMP PUSHBUTTON BOARD	MAR 2019	01111113	$5.00
DIODE CURVE PLOTTER	MAR 2019	04112181	$7.50

NEW PCBs

FLIP-DOT COIL	APR 2019	19111181	$5.00
FLIP-DOT PIXEL (INCLUDES 16 PIXELS)	APR 2019	19111182	$5.00
FLIP-DOT FRAME (INCLUDES 8 FRAMES)	APR 2019	19111183	$5.00
FLIP-DOT DRIVER	APR 2019	19111184	$5.00
FLIP-DOT (SET OF ALL FOUR PCBS)	APR 2019	SC4950	$17.50
iCESTICK VGA ADAPTOR	APR 2019	02103191	$2.50

WE ALSO SELL AN A2 REACTANCE WALLCHART, RADIO, TV & HOBBIES DVD PLUS VARIOUS BOOKs IN THE "Books, DVDs, etc" PAGE AT SILICONCHIP.COM.AU/SHOP/3

PRODUCT SHOWCASE

16-bit HD mode now standard for Rohde & Schwarz RTE, RTO and RTP 'scopes

Starting immediately, all Rohde & Schwarz RTO and R&S RTP oscilloscopes are delivered with the high definition mode featuring 16-bit vertical resolution. Users benefit from more measurement performance at the same price. Higher-resolution waveforms enable more precise analysis of signal details that would otherwise be hidden by noise.

The high definition mode increases the vertical resolution up to 16-bit.

In power electronics, it is frequently the smallest details of a signal that are of interest, also for high amplitude signals, ie, when characterising switching power supplies. A high vertical resolution is necessary to measure small details of a signal with an amplitude up to several hundred volts.

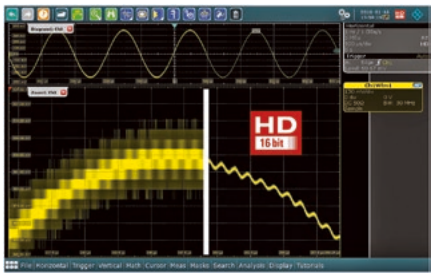
Rohde & Schwarz oscilloscopes accomplish this with a hardware lowpass filter that filters the signal after the A/D converter. The filter reduces the noise power, effectively increasing the signal-to-noise ratio and increases the resolution up to 16-bit.

The bandwidth of the lowpass filter can be variably adjusted from 10kHz to a maximum of 2GHz to match the characteristics of the applied signal. The lower the filter bandwidth, the more the signal-to-noise ratio is improved. Waveforms are displayed in a higher resolution, showing signal details that would otherwise be hidden by noise.

Thanks to the low-noise frontend and highly accurate single-core A/D converter, Rohde & Schwarz oscilloscopes have an excellent dynamic range and measurement accuracy.

Since hardware lowpass filtering takes place in real time, acquisition and processing rates remain high and the measurement results are available quickly. All analysis tools, including automatic measurements, FFT and the history mode, can be used in high definition mode.

High definition mode makes even the smallest signal details visible. The highly sensitive Rohde & Schwarz digital trigger system allows users to easily isolate these details and investigate them in greater detail.

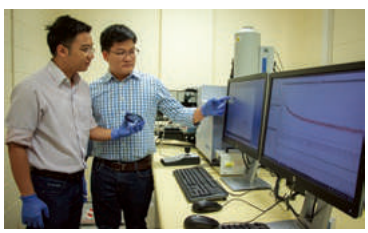


Each of the up to 16-bit samples is checked against the trigger conditions and can initiate a trigger. This means the oscilloscopes are able to trigger on even the smallest signal amplitudes.

There are no unexpected aliasing effects in high definition mode. Since high definition mode is not based on decimation, the increase in resolution is not accompanied by a reduction in the sampling rate. When high definition mode is switched on, the full sampling rate can be used, ensuring the best possible time resolution.

Contact:
Rohde & Schwarz (Aust) Pty Ltd
Unit 2, 75 Epping Rd, Lane Cove NSW 2113
Tel: (02) 8874 5188
Web: www.rohde-schwarz.com/oscilloscopes

ANU at the forefront of groundbreaking solar research



Scientists at The Australian National University (ANU) have made a fresh series of breakthroughs that could help further revolutionise solar technology – making it more efficient, and more accessible – following major discoveries last year.

The team from ANU have been concentrating on the solar cell's skin layer, which is 1000 times thinner than a human hair, and is used to conduct electricity and protect the solar cell. Previously, much of the research in this field has focused on improving the body of the cells.

Lead researcher Dr Hieu Nguyen said when hydrogen atoms are injected into a solar cell's skin, rather than the cell body, the performance of the entire structure is boosted significantly.

The ANU researchers initially discovered the skin layer can emit light with some very distinct qualities.

They quickly realised the presence of hydrogen atoms dramatically changes the characteristics of this light – information that can then be used to understand what's going on inside the skin.

Contact:
ANU College of Engineering and Computer Science
East Road, Acton, Canberra 2601
Tel: 0424 711 703
Website: anu.edu.au

New eBook from Mouser and Molex Explores the Connected Home

Mouser Electronics, Inc, in collaboration with Molex has a fascinating new eBook, "Welcoming the Connected Home".

In the new eBook, subject matter experts examine upcoming and future trends in home automation and strategies for designing Internet of Things (IoT)-enabled devices, as well as specific smart home solutions from Molex.

From connected devices like light bulbs and appliances to security systems and home assistants, the smart home is allowing residents to interact with and program their living spaces to predict and react to their needs.

The new eBook covers topics related to the connected home, exploring both current strategies as well as future possibilities. It includes tips on how to connect devices to the IoT, an exploration of upcoming capabilities in intelligent integration, and a survey of Molex products designed to serve specific smart home applications.

Molex products help engineers design intelligent and integrated smart home systems which support a wide range of home automation applications including antennas, wire-to-wire connectors, cable assemblies, capacitive switches, LED displays, and USB type-C connectors. SC

To read the ebook, visit:
www.mouser.com/news/molex-ebook-2019/mobile/index.html

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Connecting Micromite Plus to Windows 7

Recently, the Windows 7 installation on my PC became seriously corrupted. I had to go through the repair process which unfortunately interferes with the installed drivers. Although most USB devices worked normally after this, when I plugged a Micromite Plus device (August 2016; siliconchip.com.au/Article/10040) into my computer, it could not find a suitable driver.

I spent some time looking around for a separately installable driver to solve the problem, even though I thought that the PIC32 would automatically install one when connected to the USB port, but I couldn't find a suitable driver. I also tried plugging the Micromite Plus into two other Windows 7 computers with the same result.

Finally, I tried the Micromite Plus on a Windows 10 box. It worked straight away. Does this mean that the Micromite Plus is no longer supported by Windows 7? (J. W., Marsfield, NSW)

● We found the following text on page 42 of the Micromite Plus manual, regarding the USB console:

The protocol used is the CDC (Communication Device Class) protocol and there is native support for this in Windows 10, Linux (the cdc-acm driver) and macOS. Mac users can refer to the document "Using Serial Over USB on the Macintosh" on http://geoffg.net/maximite.html

If you are using Windows you will need to install the Windows Serial Port Driver (available from http://geoffg.net/maximite.html#Downloads). Full instructions are included in the download and when you have finished you should see the connection in Device Manager as a numbered communications port.

So this explains why the device worked when plugged into a Windows 10 computer – you don't need to install a driver manually, but you do for Windows 7. Your Windows Repair must have removed the driver you already had but re-installing it should fix that.

Unfortunately, the download link given no longer seems to work but you can download this same Windows Serial Port Driver from Geoff Graham's website at: http://geoffg.net/maximite.html#Downloads

Building the GPS Analog Clock

I am enthusiastic about modifying analog wall clocks and a friend of mine recommend that I build the GPS-Synchronised Analog Clock adaptor, based on your March 2009 design, using the Altronics K1129 kit. I would appreciate if you help me how to get a hold of the complete kit or PCB for that project. (A. R., via email)

● Unfortunately, Altronics have discontinued the kit for that project. We published a revised version of that project in our February 2017 issue (siliconchip.com.au/Article/10527) and you can purchase the PCB, programmed microcontroller and some other components for that version from our Online Shop at: siliconchip.com.au/Shop/8/4160

Incorrect measurement on Super-7 AM Radio

I have built the Super-7 AM Radio which you published in your November & December 2017 issues (siliconchip.com.au/Series/321) and I am having a problem with the alignment procedure.

On page 70 of the December 2017 issue, there is a table showing the expected voltages at various test points on the PCB. I have measured the voltages on my unit and get very close agreement, except for TP8. The reading I get is about 1-2V but the value is not stable. The article says that TP8 should be about 4.3V. I cannot work out why the reading I get is so different.

Could I have a faulty transistor or diode D2? I also measured the current drain as described on page 70 and obtained a reading of 4.3mA which I thought is OK. I hope you can help with my problem. (P. V., Tarneit, Vic)

● You could have a bad solder joint on one of the pins of Q5, Q6, D2 or VR2.

Modifying BackPack V2 for GPS Frequency Reference

I am constructing the GPS-Synced Frequency Reference as per SILICON CHIP, October & November 2018 (siliconchip.com.au/Series/326).

I have already built the Micromite LCD BackPack V2 (May 2017; siliconchip.com.au/Article/10652) with Mosfets Q1 and Q2 installed.

On page 79 of the November 2018 issue, there is a reference to the fact that pin 26 of the Micromite BackPack cannot be used for software controlled backlight. It says to omit Q1 and Q2 and fit the 100Ω potentiometer for backlight control instead.

Since my BackPack already has Q1 and Q2 fitted, does this mean that I have to remove these two components? (C. L., Chapel Hill, Qld)

● You only need to remove Q1 and its associated 10kΩ pull-up resistor.

Alternatively, you could cut the track to the gate of Q1 (the pin nearest the bottom edge of the PCB) and leave it in place.

Q2 then won't do anything as Q1 will not be driving its gate; it will remain switched off due to the 1kΩ gate pull-up resistor.

You will still need to fit potentiometer VR1 to control the backlight, or you could merely fit a wire link in its place, if you want the backlight to remain on at full brightness whenever the device is powered.

Alternatively, VR2 could have an intermittent wiper. The problem could also be with the jack socket, CON2. Make sure the pins make a connection on both sides of the PCB. A problem there can cause the loudspeaker connection, via the switch contacts in the socket, to be intermittent.

Modifying CLASSiC-D for different transformer

I have built your CLASSiC-D Class-D amplifier module from the November & December 2012 issues (www.siliconchip.com.au/Series/17).

I am running it from a power supply which I built using a 30-0-30VAC 300VA toroidal torrid transformer. This seems to power the CLASSiC-D amplifier module OK, even though it has ±42V rails rather than the specified ±50V.

Should I change any of the component values to better suit the lower supply voltages? (B. C., Melbourne, Vic)

● As you have discovered, the amplifier will work OK with the components designed for ±50V DC supply rails, with your slightly lower ±42V DC supply rails.

However, you could make the following component changes to optimise its performance with your particular power supply:

Rf: 5.1kΩ; **R2A, R2B, R3A, R3B:** 3.9kΩ 1W; **R4:** 33kΩ; **R5:** 3.3kΩ; **R6:** 7.5kΩ, **R7:** 8.2kΩ, **R8:** 2kΩ, **R9:** 5.6kΩ, **R10:** 470Ω 1W; **ZD5:** 56V 1W; **ZD6:** 33V 1W

Driveway Monitor not always reliable at range

I recently built your latest Driveway Monitor (July and August 2015; siliconchip.com.au/Series/288) using the Altronics K4035 kit.

I am very impressed with its performance. However, from time to time, passing cars are not detected, and I find the lack of any status indications on either box quite frustrating.

When cars are missed, I first check that the receiver has power, but if that is OK, I have the 60m walk with a screwdriver to get the lid off the detector to check what I can there.

I can't help thinking it would be of great benefit to add a periodic status transmission from the detector which the receiver would pick up and blink its green or red LEDs to indicate that communications are either good or bad.

It may also be possible to re-transmit the last message in case it was missed (but the receiver would need a way to avoid sounding the alarm twice). Do you think this could be a candidate for a future software update?

Since there is a hill in the middle of the 60m distance from the entrance to our driveway to our house, I have had to drill holes in the boxes to extend the antennas to a full wavelength.

Unfortunately, it's difficult to orientate the antennas of the two units in the same plane. And despite the longer antennas, I am still having this reception reliability problem.

In your Weatherduino Pro2 Wireless Weather Station project (March-June 2015; siliconchip.com.au/Series/285), you used 433MHz antennas purchased from eBay for the same frequency. Would such antennas help me achieve more consistent reception? (P. B., Craignish, Qld)

● It would be possible to send a periodic transmission as a way of checking that the RF link is working. We will look into adding that to the software. We're planning to publish a solar-powered repeater design which you could place at the top of your hill to solve the line-of-sight problem.

Note that missed vehicles could be the result of the vehicle being too far from the Driveway Monitor. Make sure that the detector is placed on a narrow part of the driveway and as close to the edge as possible.

Purpose-designed 433MHz antennas probably would give better results

Ultrasonic Anti-Fouling lead length and protecting drive components

We intend to sail to New Zealand later this month. Once there, I am going to order a kit for your Ultrasonic Anti-Fouling MkII design (May and June 2017; siliconchip.com.au/Series/312) from Jaycar, including the additional parts for a second transducer.

I have a question concerning the lengths of the transducer cables. Can a transducer cable be shortened? Based on reading the article, I have already figured out where to locate the transducers and the control box. The cable run to the aft transducer is likely to be less than two metres (although I haven't measured it exactly yet).

Given that the transducer cable carries AC, coiling the excess wire is likely not an option. My question – can the cable be shortened? What about replacing the plug?

Ultrasonic anti-fouling must have a future role to play in reducing the amount of toxins being leached from our hulls into the marine environment.

But there are significant submerged parts of a vessel that do not benefit from the anti-fouling action of the kit as sold – the drive train: shaft/sail drive and propeller. These parts are "insulated" from the hull by rubber blocks and diaphragms.

Do you know whether the designers of the current kit envisage a low powered version, with a smaller transducer? Such a transducer could be bolted to an engine and/or a sail drive. (D. P., Noumea, New Caledonia)

● The excess transducer wire length is usually coiled up and tucked away. The wire coiling does not affect operation.

You can reduce the wire length and reattach the end connector instead but it's extra work.

We haven't produced a smaller ultrasonic anti-fouling unit to cater for unprotected parts of a boat such as the propeller or rudder.

It has been found that the ultrasonic vibration of the boat hull does protect these parts anyway, due to the transmission of the ultrasonic waves through the water.

Boats fitted with the Ultrasonic Anti-Fouling unit do still need to be occasionally hauled out of the water for marine growth to be scraped off but the intervals usually are much longer than without it, and the growth is not usually anywhere near as bad.

You are right that this should lead to a significant reduction in toxins being released into seawater.

than simple wire whip antennas.

While half-wave and full-wave antennas are better than quarter-wave, directional antennas are usually better again. A 433MHz Yagi mounted up high would probably give the best results, especially if it was high enough to achieve line-of-sight.

Ultimately, getting reliable 433MHz reception from such low-power modules over 60m without line-of-sight requires careful antenna design and arrangement.

Full-Wave Motor Speed Controller transformer

I want to build the Full Wave Universal Motor Speed Controller (March 2018; siliconchip.com.au/Article/10998) but RS Australia has the Talema AX-1000 current sensing transformer on back-order until July. Other vendors seem to have a similar stock situation. Is there another device I can use instead? (P. W., Keilor East, Vic)

- The AX-1000 (RS Cat 173-0057) is currently back in stock. RS Cat 124-3900 is a "house brand" version of the AX-1000 transformer and is also currently in stock.

Alternatively, there is the Talema AP-1000 current transformer (RS Cat 775-4943). It appears to be similar to the AX-1000 we specified but it's difficult to say for sure since the AP-1000 data sheet only shows its output characteristics with a 10Ω load. Its output may be similar to the AX-1000 if the load is 510Ω, as in our circuit.

Given its low price, you could give it a try, although we can't guarantee that the AP-1000 will give equivalent feedback control for the motor. Although it appears physically identical to the AX-1000.

Inductor for Majestic speaker crossover

I am interested in building a pair of Majestic speakers (June & September 2014; siliconchip.com.au/Series/275) but the 2.7mH inductor is out of stock. Please advise where I can get a suitable replacement.

Also, it looks like Jaycar still has the LF1330 former, so alternatively advise the number of turns and wire gauge required to create an equivalent substitute. (B. D., Ashburton, Vic)

- We had an article explaining how to wind the inductor yourself in the June 2016 issue (pages 72-75; siliconchip.com.au/Article/9965). We used 325 turns of 18-20 gauge wire on a former with a 25mm inner diameter, 67mm outer diameter and 25mm height. You can also get pre-wound inductors from www.soundlabsgroup.com.au

Majestic Speaker design questions

I built your Majestic Loudspeakers (June & September 2014; siliconchip.com.au/Series/275) in 2015 and am still enjoying them but I have some questions about the design.

Firstly, why is your crossover frequency 1.6kHz (@6dB/octave) when the Etone 1525 woofer can handle frequencies up to about 2.2-2.4kHz? On the Celestion website (https://celestion.com/product/48/cdx11730/), they recommend that the CDX1-1370 compression tweeter is crossed over at 2.2kHz for a 6dB/octave filter. Could 1.6kHz be too low for the tweeter?

Also, why did you choose the CDX1-1730 when the CDX1-1425 & 1430 (using the same neodymium magnet) have flatter frequency re-

YOU ASKED FOR IT . . . WE'VE DELIVERED!

The Vintage Radio Collection from the pages of SILICON CHIP

"Vintage Radio" is one of the most popular columns which appears every month in Australia's most-read and authoritative electronics magazine, SILICON CHIP.

Over the years many readers have asked us if there was a single source for all "Vintage Radio" articles so a particular set or sets they have managed to get hold of could be referenced. Until now, that was not possible.

But now it is!

We've put together a DVD# containing every "Vintage Radio" column for more than 20 years – from April 1997 right through to December 2018 – and included an easy-to-read index so you can find the one you're looking for. They're all provided in PDF format so the quality is even better than in the magazine (you can actually read many dials!). And there's much more than radios – there's articles on vintage TVs, amplifiers... all from a bygone era!

Physical DVD:
In paper sleeve – $55
In deluxe case (As seen above) **– $60**
(Plus $10 p&p within Australia)
Downloaded copy – $50

#To view, requires Adobe Acrobat on your computer (free to download): https://get.adobe.com/reader/
Cannot be used with an audio DVD Player

Exclusively available from SILICON CHIP: www.siliconchip.com.au/shop

Mains Soft Starter not effective after multiple re-starts

I recently built your Soft Starter for Power Tools from the July 2012 issue (siliconchip.com.au/Article/601). I built it from an Altronics K6043 kit which I purchased from Tronixlabs.

I have never seen such clear and detailed instructions! I only found one typo – in the parts list, it should read "2 IN4148 small signal diodes (D3,D4)", not "(D4,D4)".

It works OK but right at the very end of the blurb it states that "if you start the tool multiple times in quick succession, the second and later starts will not have as effective current limiting due to the thermistors heating up".

Indeed so. I have connected it to a Ryobi table saw. It works well on the first start but quickly diminishes if I use it again, even a few minutes after. This is very frustrating and kind of defeats the purpose of the unit.

Do you have any workarounds/fixes? A small fan in the box perhaps? Is there any kind of heat sink, or a bigger (metal?) box that would help? (D. R., via email)

● The heating effect you are describing is much larger than what we experienced with the prototype. That may be because your table saw has a much longer spin-up time than the power tools we were testing it with and so causes the thermistor to heat up more.

We agree that a fan sucking air out of the box with holes drilled in the other end to allow fresh air to enter would be the best solution.

You would need to fit the unit into a larger box to accommodate the fan. Be careful to keep the holes small so that fingers, bits of wire and so on can't find their way inside the box and contact any mains-carrying conductors.

The best solution would be to run a small 230/240VAC rated fan directly off the incoming mains. However, it would also be possible to use a 24V DC fan connected between the +12V and -12V rails.

To provide sufficient current to power a DC fan in this manner, you would need to increase the value of the 330nF X2 capacitor substantially. Using a 1µF X2 capacitor in its place would give you around 40mA to run the fan (20V × 40mA = 0.8W). We suggest also increasing the 220µF 16V capacitors to 470µF 16V.

Altronics Cat F1046 is a 50mm, 24VDC fan which draws around 60mA nominal at 24V DC. This should drop to around 50mA at 20V; a 100Ω series resistor would probably reduce its current to the point where the circuit will operate normally with the aforementioned changes.

sponses? Is it because the CDX1-1425 & 1430 are more expensive than the CDX1-1730?

Finally, I am planning to change my Majestic speakers over to use an active crossover. Should I increase the crossover frequency, say, to 2kHz? (J. S., Melbourne, Vic)

● Loudspeaker design is a complex process and you can't really design speakers based on the specifications of the components, since there are so many interactions (electrical and acoustic). It's therefore not all that easy to answer your questions, but we will try.

Firstly, it may be true that the Etone 1525 woofer "can handle" frequencies up to 2.4kHz but our own measurements of its free-air frequency response show quite a significant dip just above 2kHz.

We therefore decided that to get a flat response, the crossover frequency should be below 2kHz.

It's generally bad practice to have a crossover frequency too close to the -3dB point of any driver, since the crossover is usually designed with the assumption that the driver's response is more or less flat up to the crossover frequency; otherwise, you will get a dip in the overall response. So you will usually choose a crossover frequency where both drivers are down by 1dB or less.

The resonance of the CDX1-1730 tweeter is approximately 500Hz, so our use of a 1.6kHz crossover frequency does not pose any problems for the tweeter. The manufacturer has quoted 2.2kHz as a recommended minimum crossover frequency but we feel that this is very conservative!

The CDX1-1730 was chosen for its fantastic performance and sheer power handling capability (75W RMS), enabling the Majestics to handle up to 300W RMS without damage while still maintaining an excellent frequency response. We tested them at the full 300W (attracting some unwanted attention from the Police!). The tweeters handled their share with ease.

Unfortunately, the CDX1-1425 is listed in the manufacturer's official specifications as having a power rating of only 25W RMS and with 2dB less sensitivity compared to the CDX1-1730.

Looking at the frequency response data, there is almost no difference between the 1730 and the 1425. It all depends on the type of horn used. Celestion gives responses for a plane wave tube and also for an exponential horn (90° x 40°). The differences between the tweeters' performance with those two horns are far greater than the differences between the two tweeters.

Ultimately, we chose the combination of drivers not just because of their specifications but also because we conducted many listening tests with different woofers, tweeters and horns and we found that this combination gave the best overall sound quality as well as measuring up well.

Internet specifications vary enormously for these tweeters and we are not sure where you obtained the lower frequency limit because Celestion quote the "frequency range" for the CDX1-1730 as 1200-20,000Hz but the CDX1-1425 response is quoted as 2,000-20,000Hz.

Because of its lower sensitivity and power handling, we do not recommend the CDX1-1425 tweeter for the Majestic system.

One of the benefits of using an active crossover (such as our September/October 2017 design; siliconchip.com.au/Series/318) is that they are usually adjustable so you can try out different crossover frequencies and see which sounds best.

We suggest you stick with the 1.6kHz crossover frequency used in our design; however, you will probably get reasonable results anywhere between 1.5kHz and 2kHz. SC

MARKET CENTRE

Cash in your surplus gear. Advertise it here in SILICON CHIP

FOR SALE

BUSINESS FOR SALE
WELL KNOWN AUSTRALIAN ELECTRONICS COMPANY FOR UNDER $100,000 GENUINE BUYERS ONLY:
zzk2017@outlook.com

tronixlabs.com.au – Australia's best value for supported hobbyist electronics from Adafruit, SparkFun, Arduino, Freetronics, Raspberry Pi – along with kits, components and much more – with same-day shipping.

LEDs, BRAND NAME and generic LEDs. Heatsinks, fans, LED drivers, power supplies, LED ribbon, kits, components, hardware, EL wire.
www.ledsales.com.au

PCB PRODUCTION

PCB MANUFACTURE: single to multilayer. Bare board tested. One-offs to any quantity. 48 hour service. Artwork design. Excellent prices.
Check out our specials:
www.ldelectronics.com.au

KIT ASSEMBLY & REPAIR

KEITH RIPPON KIT ASSEMBLY & REPAIR:
* Australia & New Zealand;
* Small production runs.
Phone Keith: 0409 662 794
keith.rippon@gmail.com

DAVE THOMPSON (the Serviceman from SILICON CHIP) is available to help you with kit assembly, project troubleshooting, general electronics and custom design work. No job too small. Based in Christchurch, NZ but service available Australia/NZ wide.
Email dave@davethompson.co.nz

VINTAGE RADIO REPAIRS: electrical mechanical fitter with 36 years experience and extensive knowledge of valve and transistor radios. Professional and reliable repairs. All workmanship guaranteed.
$17 inspection fee plus charges for parts and labour as required. Labour fees $38 p/h. Pensioner discounts available on application.
Contact Alan, VK2FALW on 0425 122 415 or email bigalradioshack@gmail.com

WANTED

Speaker enthusiast needs a copy of a book once sold by Jaycar entitled "High Power Loud Speaker Enclosure Design & construction". It had a catalogue number BC1166.

Will pay $50 (including postage) to the first person who has a pristine copy, i.e., little use but slight dog ears ok.

Contact Melanie (on behalf of inquirer on 02 8832 3100)

MISCELLANEOUS

ASSORTED BOOKS FOR $5 EACH
Selling assorted books on electronics and other related subjects like audio, video, programming etc. The books are relatively old in most cases and vary in condition.
You'll need to come in person to see what books we have and what we're willing to sell:
SILICON CHIP
1/234 Harbord Road (up the ramp)
Brookvale NSW 2100
(02) 9939 3295

ADVERTISING IN MARKET CENTRE

Classified Ad Rates: $32.00 for up to 20 words (punctuation not charged) plus $1.20 for each additional word. Display ads in Market Centre (minimum 2cm deep, maximum 10cm deep): $82.50 per column centimetre per insertion. All prices include GST. Closing date: 5 weeks prior to month of sale. To book, email the text to silicon@siliconchip.com.au and include your name, address & credit card details, or phone Glyn (02) 9939 3295 or 0431 792 293.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely. Readers are warned that high voltage wiring should be carried out according to the instructions in the articles.

When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

Advertisers are warned that they are responsible for the content of all advertisements and that they must conform to the Competition & Consumer Act 2010 or as subsequently amended and to any governmental regulations which are applicable.

Coming up in Silicon Chip

AD584-based precision voltage references
Jim Rowe looks at three low-cost but very precise voltage references, all based on the Analog Devices AD584 IC. They can provide very stable 2.5V, 5V, 7.5V or 10V reference outputs, which can be trimmed to within a fraction of a millivolt of the ideal reading.

Australian International Airshow 2019
Dr David Maddison attended the biennial Avalon airshow and will describe all the latest technology (military and civilian) presented at this world-class aviation showcase.

Bathymetry through the ages
Dr David Maddison describes how the use of knotted ropes and timber poles to measure water depth gave way to sonar. But modern sonar is about more than just water depth measurement. It can be used to map the seafloor, for discovering and imaging wrecks and other submerged objects.

High-current linear bench supply
This power supply has low ripple and noise due to the use of linear regulation. But it can still deliver plenty of current (more than 5A) with an output of up to 50V.

Using 3.5-inch touchscreens with Arduino & Micromite
We've used 2.8-inch touchscreens extensively over the last few years but larger displays with a significantly higher resolution are now available with reasonable price tags. They use the same SPI interface and so can easily be hooked up to and controlled by an Arduino or Micromite board.

UHF repeater
Based on reader requests, this device extends the range for devices such as our 2015 Driveway Monitor which use UHF transmissions to send data from a remote unit to a base station. It can both extend the usable range and also solves line-of-sight problems caused by hills or obstacles that are in the way of the signal.

Note: these features are planned or are in preparation and should appear within the next few issues of Silicon Chip.

The May 2019 issue is due on sale in newsagents by Thursday, April 25th. Expect postal delivery of subscription copies in Australia between April 23rd and May 10th.

Advertising Index

Altronics 66-69
Ampec Technologies 9
Cypher Research Labs 10
Dave Thompson 95
Digi-Key Electronics 3
Emona ..... IBC
Hare & Forbes ..... OBC
Jaycar IFC,45-52
Keith Rippon Kit Assembly 95
LD Electronics 95
LEACH Co Ltd 79
LEDsales 95
METCASE Enclosures 6
Microchip Technology 11,75
Mouser Electronics 5
Ocean Controls 13
Philips 8
Rayming PCB & Assembly 4
Rohde & Schwarz 7
SC Vintage Radio DVD 93
Silicon Chip Shop 88-89
The Loudspeaker Kit.com 55
Tronixlabs 95
Vintage Radio Repairs 95
Wagner Electronics 12

Notes & Errata

DAB+/FM/AM radio, February 2019: in the parts list on page 85, we wrongly described the BC817 transistors as PNP and BC807 as NPN. BC817s are NPN and BC807s are PNP. The type numbers and part designators given are otherwise correct. Also, note that the 5.5 turn side of T1 is terminated on the CON6 side, as described in the text; this is not clear from Fig.2.
Four-channel sound system using a single woofer, Circuit Notebook, February 2019: the circuit diagram does not show the part type for ICs3-9. The author recommends LM833 although NE5532 should also be suitable.
Low Voltage DC Motor and Pump Controller, October & December 2018: for PWM frequencies above 1kHz, a 30V+ schottky diode must be connected across the fan/pump, cathode to positive, with a current rating at least half the load's maximum. Solder it across the unit's outputs or the fan/pump terminals. This prevents the Mosfets from overheating when they absorb the back-EMF pulses. We also suggest that you solder 10µF 25V X5R capacitors on top of the 100nF bypass capacitors for IC2 and IC3 and add a 2200µF 25V low-ESR electrolytic between the +12VF and 0V (fan power input) terminals on the board. Note that the loads may run briefly when power is first applied; disconnect all loads before making a connection to CON2 (ICSP).
USB Port Protector, May 2018: TVS2 has a metal tab under its body which is not mentioned in the article, and depending on how you fit it, it could become shorted out. Make sure that this tab only makes contact with one of the two pads before soldering it in place.

"Rigol Offer Australia's Best Value Test Instruments"

Oscilloscopes

RIGOL DS-1000E Series

- 50MHz & 100MHz, 2 Ch
- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

FROM $379 ex GST

RIGOL DS-1000Z Series

- 50MHz, 70MHz & 100MHz, 4 Ch
- 1GS/s Real Time Sampling
- 24Mpts Standard Memory Depth

FROM $579 ex GST

RIGOL DS-2000E/A Series

- 70MHz, 100MHz & 200MHz, 2 Ch
- 1GS/s & 2GS/s Real Time Sampling
- From 14Mpts Memory Depth

FROM $912 ex GST

Function/Arbitrary Function Generators

RIGOL DG-1022

- 20MHz Maximum Output Frequency
- 2 Output Channels
- USB Device & USB Host

ONLY $539 ex GST

RIGOL DG-1000Z Series

- 25MHz, 30MHz & 60MHz
- 2 Output Channels
- 160 In-Built Waveforms

FROM $517 ex GST

Multimeters

RIGOL DM-3058E

- 5 1/2 Digit
- 9 Functions
- USB & RS232

ONLY $673 ex GST

Power Supplies

RIGOL DP-832

- Triple Output 30V/3A & 5V/3A
- Large 3.5 inch TFT Display
- USB Device, USB Host, LAN & RS232

ONLY $649 ex GST

Spectrum Analysers

RIGOL DSA Series

- 500MHz to 7.5GHz
- RBW settable down to 10 Hz
- Optional Tracking Generator

FROM $999 ex GST

Real-Time Analysers

RIGOL RSA-5000 Series

- 9kHz to 3.2GHz & 6.5GHz
- RBW settable down to 1 Hz
- Optional Tracking Generator

FROM $11,499 ex GST

Buy on-line at www.emona.com.au/rigol

Sydney
Tel 02 9519 3933
Fax 02 9550 1378

Melbourne
Tel 03 9889 0427
Fax 03 9889 0715

Brisbane
Tel 07 3392 7170
Fax 07 3848 9046

Adelaide
Tel 08 8363 5733
Fax 08 83635799

Perth
Tel 08 9361 4200
Fax 08 9361 4300

EMONA

email testinst@emona.com.au

web www.emona.com.au

HARE & FORBES MACHINERYHOUSE

"Setting the standard for Quality & Value"

A family owned Australian business
Established 1930

THE INDUSTRY'S CHOICE!

CNC Machinery | Metal Working | Sheet Metal Fabrication | Wood Working | Workshop & Automotive | Lifting Handling | Cutting Tools | Machine Tool Accessories | Measuring Equipment

Pick Up Tool with Magnetic Head & 1 x LED Light

- 1 x LED light
- 620mm length
- Flexible spring jaw head
- Claw can grip up to 30mm round objects
- Ø14.8mm magnetic head
- Includes 3 x LR44 batteries

$14 ~~$16.50~~ (M0010)

Handy Workshop Tips & Techniques

- 324 coloured pages
- "Covers all you need to know about anything you need to do in your workshop"

$33 ~~$39~~ (L345)

RFM-1500 Anti-Fatigue Rubber Mat

- 1505 x 905mm (8mm thick)
- Workshop or ute
- Tapered edge

$33 ~~$44~~ (M800)

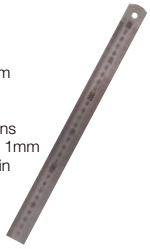
UTS-1 Universal Tool Stand

- 200kg load capacity
- 335 x 590 top
- 770mm height

$33 ~~$38.50~~ (W810)

70-621 Steel Rule

- 300mm with 0.5 & 1mm graduations
- 12" with 32nds, 64ths, 16ths & 8ths graduations
- Overall size 300 x 25 x 1mm
- Stainless steel with satin chrome finish



$9 ~~$11~~ (Q621)

WHG-6 Digital Height Gauge

- 0 - 150mm measuring range
- Ideal for saw blades & routers
- DRO in mm, inches & fractions
- 0.01mm resolution
- Auto on & shut-off

$33 ~~$39.60~~ (W643)

Digital Caliper

- 150mm / 6"
- Metric, inch & fraction
- 4-way measuring
- Includes battery

$29 ~~$38.50~~ (M738)

DB-180 Digital Bevel Box

- 180° range
- Auto shut off
- Magnetic base
- 0.1° resolution

$59 ~~$77~~ (M977)

Punch & Cold Chisel Set

- 5 x cold chisels
- 4 x pin punches
- 4 x tapered punches
- 1 x centre punch

$56 ~~$66~~ (P364)

CB6-5S Carbide Burr Double Cut Set

- 5 piece set
- Industrial quality double cut burrs
- SD-3, SE-3, SA-3, SC-3, SF-5
- Ø1/4" x 1-1/2" shank

$69 ~~$82.50~~ (B900)

Metric HSS Hole Saw Set

- 11 piece set
- M42 Bi-Metal high speed steel
- 19, 22, 25, 32, 35, 38, 44, 51, 57, 64, 76mm
- Includes 3/8" & 1/2" arbor shank & pilot drill

$88 ~~$110~~ (D102)

GSP-795 Pneumatic Stool

- 675-795mm seat height
- Ø360mm padded seat
- 360° seat rotation
- 135kg capacity

$99 ~~$110~~ (A359)

ACP-155 - Automatic Centre Punch

- Ø6mm hardened steel centre punch
- Ergonomically shaped plastic body
- Curved end to fit into palm
- Automatic single hand operation

$19 ~~$22~~ (P368)

SFH-N40 Soft Face Hammer

- Ø40mm soft faces
- 2 x Plastic inserts
- 1 x Nylon insert
- 1 x Brass insert
- 250mm hickory handle

$29 ~~$38.50~~ (H870)

SFH-D40 - Dead Blow, Nylon Face Hammer

- Shot filled steel head
- 40mm nylon faces
- 250mm hickory handle
- Handle pinned to head

$35 ~~$47.30~~ (H880)

ABR-7 Auto Panel Restoration Kit

- Drop forged, heat treated steel
- Dollies: utility, curved, heel, double ended hand
- Hammers: Crown face + pick
- Flat face + straight pein,
- Double ended shrinking

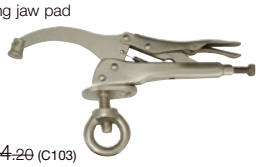
$99 ~~$108.90~~ (H885)

ALL THIS & MORE IN STORE & ONLINE

- MARK
Staff Member

9" Drill Press Locking Clamp

- 2" jaw opening
- Quick release lever
- Swivelling jaw pad



$20 ~~$24.20~~ (C103)

Deluxe Drill Press Vice

- Made from cast iron
- Hardened jaws
- 127mm jaw width
- 120mm opening

$88 ~~$110~~ (V145)

BD-325 Bench Drill

- 16mm drill capacity
- 2MT spindle
- 12 spindle speeds
- Swivel & tilt table
- 1hp, 240V motor

$319 ~~$352~~ (D590)

UNIQUE PROMO CODE

SC419

ONLINE OR INSTORE!

VIEW AND PURCHASE THESE ITEMS ONLINE AT
www.machineryhouse.com.au/SC419

BECOME A MACHINERYHOUSE MATE
www.machineryhouse.com.au/signup

$70 FREE DISCOUNT VOUCHERS

SYDNEY
(02) 9890 9111
1/2 Windsor Rd, Northmead

BRISBANE
(07) 3715 2200
625 Boundary Rd, Coopers Plains

MELBOURNE
(03) 9212 4422
4 Abbotts Rd, Dandenong

PERTH
(08) 9373 9999
11 Valentine St, Kewdale

04_SC_280319

Specifications & Prices are subject to change without notification. All prices include GST and valid until 30-04-19